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EXTENSIVE SHOP ENLARGEMENT is contemplated by the Lehigh Valley R. R. for its shops at Sayre, Pa. The shop capacity of the road is insufficient for the large amount of heavy locomotive repairs, and it is proposed to extend the facilities at Sayre to take care of this work. A new locomotive repair shop, 366 × 749 ft., a blacksmith shop 103 × 363 ft., a storehouse 103 × 363 ft., and a central power plant. The locomotive repair shop will consist of a central machine shop, a covered storage yard at each side of this, and two erecting shops outside of these, while the boiler shop will form one end of the whole structure. The buildings will generally have concrete foundations, brick walls, steel frame and roof trusses, slag roofing laid on reinforced concrete, and floors of wood planking on concrete, except in the blacksmith shop where a cinder floor will be used. The main shop will be heated on the hot-air blower system, while the other buildings will have direct steam radiation. All the machinery will be driven by electric motors, using a combination of individual and group driving. All this work will probably be done in the next two years, but the plan is to extend the shops in the following years so as to build up gradually a plant comprising three groups of buildings, respectively for the repair of locomotives, passenger cars and freight cars. As above noted, the locomotive shops are the first part of the plant to be built, at a cost of over $1,000,000. The design, construction and equipment of the new shop is in charge of Mr. W. G. Berg, Chief Engineer, and Mr. H. D. Taylor, Superintendent of Motive Power, Lehigh Valley R. R.

MUNICIPAL OWNERSHIP OF STREET RAILWAYS in Illinois has been made possible through the signing, by Governor Yates, of the bill whose provisions were briefly noted in our issue of May 14. Under this act any city in the state may buy, build, operate or lease to an operating company a street railway system, provided such action is approved by popular vote, and provided that no lease shall be for a period of more than 20 years. No ordinance leasing a municipal street railway for more than five years, or renewing a lease, shall become operative within 90 days of its passage, and if within that time 10% of the voters at the last preceding mayoralty election shall so petition a referendum vote will be necessary, of which a majority must approve the lease in order to make it valid. The rates of fare of any municipal street railway must be sufficient to meet the operating expenses and the interest charges, and to provide a surplus large enough to cancel all outstanding bonds at their maturity. To pay for railways bought or built cities may issue bonds not exceeding 10% of the actual cost thereof; or they may issue interest-bearing certificates up to 10% in excess of the cost of the property, secured by a mortgage on the street railway system. Such certificates and mortgages shall not stand as a liability against the city or any city fund other than the street railway revenues. The mortgages shall carry the usual right of foreclosure and of operation for not more than 20 years thereafter by the party foreclosing. Except in the case of existing railways, no allowance for earning power or franchise shall be included in the purchase price of a street railway under this act. Accounts of municipal street railways must be kept separate from all other city accounts, and must show original cost, extensions and improvements, operating expenses, sinking fund charges, interest, depreciation, insurance, "lost taxes," and the value of any interchanges of service with other city departments. All such accounts must be submitted at least once a year to expert accountants, and a report must be published annually showing the financial results of the enterprise. The act has no force in any city until submitted to the electors and approved by a majority thereof. No bonds to buy or build a street railway can be issued unless approved by a two-thirds popular vote, while municipal operation requires a three-fifths vote.

AN ENDURANCE TEST OF FREIGHT MOTOR VEHICLES was held in New York City on May 21. Nine vehicles took part in the run, which covered a route of 30 to 40 miles, depending upon the load capacity of the vehicle. A prescribed number of stops had to be made during the run. Seven vehicles completed the run, two being disabled by accidents. The seven successful vehicles and their performances were as follows: (1) Electric delivery wagon, International Motor Car Co., of Toledo, O., load 1,200 lbs.: to cover a course of 40 miles including 100 stops. Time, 5 hrs. 18 min. (2) Steam delivery wagon, Mobile Company of America, of New York City, load 775 lbs.: distance and stops as before. Time, 5 hrs. 10 min. (3) Gasoline delivery wagon, Knox Automobile Co., of Springfield, Mass., load 1,250 lbs.: distance and stops as before. Time, 3 hrs. 41 min. (4) Gasoline delivery wagon, maker same as preceding, load 1,245 lbs.: distance and stops as before. Time, 4 hrs. 35 min. (5) Steam truck, Columbia Engineering Works, Brooklyn, N. Y., load 3,805 lbs.: to cover course of 30 miles including 25 stops. Time, 4 hrs. 57 min. (6) Steam truck, Morgan Motor Co., of Worcester, Mass., load 5,740 lbs.: distance and stops as before. Time 12 hrs. 52 min. (7) Steam truck, F. Coulthard & Co., of London, England, load 10,000 lbs.: to cover a course of 30 miles including 10 stops. Time, 10 hrs. 28 min.

THE USE OF WOOD BLOCK PAVING as an acceptable substitute for planking on the team gangways of ferry boats was suggested in an editorial in our issue of March 19 last. We learn that such paving is to be used on the new ferry boats now under construction for the North River service of the Erie R. R. at New York City, and the contract for the blocks has been awarded to the United States Wood Preserving Co., of New York City.

VULCANIZING TIMBER is a preservative process described in a recent Consular Report, which in turn quotes the Liverpool "Daily Post" of Feb. 11, as follows:

> A considerable amount of interest has been aroused by the announcement, as the result of a prolonged series of experiments, of a method of so treating timber as to secure even from soft wood a largely increased toughness and hardness. The process is described as one of vulcanizing, comparable in some respects with Bessemer's process of converting iron into steel, and is the invention of Mr. Powell, a Liverpool merchant. The treatment to which the timber is subjected is, roughly speaking, that of saturation at boiling point with a solution of sugar, the water being afterwards evaporated at a high temperature. The result is to leave the pores and interstices of the wood filled in with solid matter and the timber vulcanized, preserved, and seasoned. The nature of moderately soft wood, it is claimed, is in this way changed to a tough and hard substance, without brittleness, and also without any tendency to split or crack. It is also rendered remarkably impervious to water. Hard woods similarly treated derive similar benefits. Moreover, it is claimed that the process may be completed and timber turned out ready for use in a few days. The invention, which has been patented, is to be brought before the attention of the timber trade by a series of practical demonstrations and lectures.

FIRE DESTROYED A PINTSCH GAS PLANT at Mott Haven, New York City, on May 21. In making Pintsch gas a light oil is produced as a by-product, for whose storage until removal underground tanks are used. In the present case a quantity of this oil was stored in barrels in the yard of the plant, and from some unknown cause these took fire. The heat from the burning oil caused the failure of the roof of a large gas-holder, and the contained gas was burned. In addition four out of a battery of eight high-pressure tanks of compressed gas exploded, and portions of the compressor plant were damaged. The remainder of the gas plant, a second gas-holder, the other four high-pressure tanks and the underground tanks of crude oil and of by-product oil, remained intact. The plant is owned and operated by the New York Central & Hudson River R. R. Co.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Chesapeake & Ohio Ry. near Charlottesville, Va., on May 26. A passenger train was derailed on a high embankment and the engineer and fireman were killed.—On May 17 a train on the Denver & Rio Grande Ry. ran into a fall of rock near Grand Junction, Colo., and was wrecked. The engineer and firemen were killed.

A COAL GAS EXPLOSION ON A STEAMSHIP is reported by the steamer "Coban," bound from Newfoundland to Montreal, on May 21. The "Coban" carried a large cargo of coal, gas from which is thought to have become ignited and caused the explosion. One person was killed and much damage done to the after part of the vessel.

AN ACCIDENT TO THE BASCULE BRIDGE over the Calumet River, at 95th St., Chicago, occurred on May 8, due to the fact that the bridge was opened to traffic before being fully completed. The bridge has a system of pneumatic buffers designed to arrest the travel of the leaf in opening and closing, but at the time of the accident the trippers operating the upper buffers were not in place. As a temporary precaution, oak blocks 6 × 12 ins. were placed in the bottom of the pit, against the river pier, to act as fixed buffer blocks. Investigation after the accident showed that the blocks at the south and center trusses had dropped to the bottom of the pit, leaving only the block for the north truss in position. When the bridge was opened, the absence of the two blocks permitted the south and center trusses to travel farther than the north truss, thus causing undue torsion on the main 8-in. driving shaft, with the result that one section of this shaft (8 ft. 9 ins. in length) was broken. The new section of shaft was put in and the bridge again put in service on May 11. The bridge is of the trunnion type, 128 ft. span c. to c. of trunnions, and was described in our issue of Jan. 10, 1901; it is very similar to the Clybourne Place bridge over the Chicago River, which was described more in detail in our issue of Jan. 31, 1901.

PNEUMONIA AT CHICAGO continues to cause an alarming number of deaths. For the week ending May 16, according to the weekly bulletin of the department of health, the deaths from pneumonia numbered 172, or over 27% of the total deaths (632) from all causes. In the first 4½ months of the year there have been 2,659 deaths from pneumonia in Chicago, as compared with 1,190 from consumption. For years past pneumonia has been increasing and consumption decreasing in Chicago, and the same is true, though in less degree, for the whole United States. It has been pointed out in the bulletins of the Chicago health department that pneumonia is a communicable disease, but one whose spread, like that of consumption, can be easily restricted by carefully collecting and destroying the sputa of the patients, and by proper disinfection of articles likely to be contaminated thereby.

EXTENSIVE WEATHER DISTURBANCES took place all over the United States during the past week. The long-continued dry weather was broken by storms that at several places reached the intensity of tornadoes, and resulted in much property damage and the death of a number of people. The storms were most severe in the Mississippi Valley, over a dozen persons being killed in Nebraska and Iowa. The preceding drought, besides producing a great prospective loss in crops, endangered forests all over the country. The Adirondack region of New York State was swept by forest fires which are said to have burned over many hundreds of square miles.

AN EXPANSION JOINT for a cast-iron pipe exposed on a trestle at a river crossing is described by Prof. Thos. U. Taylor in "Irrigation Systems of Texas" (Water Supply and Irrigation Papers of the U. S. Geological Survey, No. 71). The pipe around and near each joint was heavily covered with North Carolina tar. Heavy canvas was wrapped around the tar covering, more tar applied, and finally a second layer of canvas was secured by winding wire around the whole. The original river crossings were wooden flumes, 4 ft. wide and 2 ft. high, but these leaked so badly that their sides were removed and pipe laid on the bottom of the flume. There are four of these crossings near Menardville, Tex., on an irrigation system owned by Capt. L. P. Sieker. The crossings are from 50 to 180 ft. in length, and the pipe from 12 to 18 ins. in diameter.

THE CHICAGO INTERCEPTING SEWER SYSTEM.

The completion of the Chicago Drainage Canal and the consequent reversal of flow of the Chicago River from instead of into Lake Michigan has eliminated the river (and all sewers discharging into it) as a source of pollution of the lake from which the city draws its water supply. There are, however, numerous sewers discharging directly into the lake at various points along the shore, and in 1897 plans were adopted for two systems of intercepting sewers, one on the north

Fig. 1. Map of Intercepting Sewer System of Chicago.

F. W. Blocki, Commissioner of Public Works; W. E. Quinn, Superintendent of Bureau of Sewers; Wm. S. McHarg, Consulting Engineer for Intercepting Sewer System.

and the other on the south side of the river. Each of these consists of a line of sewers running parallel with the shore, and discharging into a large sewer or conduit running west to the river, so that the sewage would be carried to the Drainage Canal. The conduit on the north side is on Lawrence Ave., leading to the north branch of the river; the one on the south side is on 39th St., and leads to the south fork of the south branch of the river. This intercepting sewer system was described in our issue of April 21, 1898, and the contracts for the two main sewers to the river were awarded April 13, with the provision that the work was to be completed by April 1, 1899, or more than three years ago. The works, however, are still uncompleted, and the date of their completion is uncertain. Under these conditions, the effect of the Drainage Canal in preventing the pollution of the lake water is largely nullified, and the quality of the water is always dubious at best, while at the present time it is a direct menace to the health of the community.

Even when the intercepting sewer system is completed, however, the water supply will still be liable to serious pollution from the Calumet River, which receives the sewage of all the district south of 87th St., as well as a great amount of factory waste, all of which is discharged into the lake. The Sanitary District has made a proposition to remedy this by means of a drainage canal to reverse the flow of the Calumet river and cause it to discharge into the present main drainage canal. (Eng. News, Dec. 4, 1902). The cost of such work would be nearly $12,000,000, but this project is as yet in an entirely indefinite shape.

We have recently obtained from Mr. Wm. S. MacHarg, Consulting Engineer for the Intercepting Sewer Division of the Bureau of Sewers, Department of Public Works, Chicago, information respecting the present status of work on the intercepting sewer system, and this information is embodied in the following general description of the various sections and the present condition of the work. Fig. 1 is a general plan of the intercepting sewers, showing the completed and uncompleted portions of the work on Dec. 12, 1902, and indicating the positions of the various sections which are referred to individually below. A more complete description of the plans with drawings and specifications, will be found in our issue of Feb. 24 and April 21, 1898.

The system is divided into three general divisions: 1, The Central division; 2, The South Side division; and, 3, The North Side division. The total length of the system will be 91,386 ft. (17.3 miles), of which 68,751 ft. (13 miles) were completed by the end of 1902.

CENTRAL DIVISION.

This division includes the district from Congress St. to 31st St. It comprises only two short sewers, forming sections A and B of the system. These however, form a very important part of the system, since they intercept about 40% of the sewage which was formerly discharged directly into the lake. These two sewers were described and illustrated in our issue of Dec. 24, 1898. Their total length is 10,610 ft. They were both completed in that year and have been in continuous service since that time.

SECTION A.—This runs under 12th St., from Michigan Ave. to State St., then south to 14th St., and west to the river. It is 3,575 ft. long, 4 to 5.5 ft. diameter, with two rings of brick. It was built in open cut. Contractor, J. H. Roach.

SECTION B.—This starts at South Park Ave. and 22d St. and runs west to Prairie Ave., north to 21st St., and west to the river. It is 7,035 ft. long, 3 to 8 ft. diameter, with two and three rings of brick. It was built in open cut. Contractors, Byrne & Shortall.

SOUTH SIDE DIVISION.

This division comprises a 20-ft. conduit from the lake to the Chicago River on 39th St. (Sections C and L) and a long intercepting sewer along the lake front from 73d St. to 39th St. (Sections G, H and K). This begins with a diameter of 12½ ft. at 73d St. and is gradually enlarged until it becomes a 16-ft. conduit at 43d St. This sewer, which is being built by the city by day labor, intercepts all lateral sewers now emptying into the lake between 39th St. and 73d St. All sewage between 39th St. and 31st St., east of State St., will be diverted to the 39th St. conduit by a 6½ ft. sewer (Section I) running along the lake shore from 35th St. and emptying into the 16-ft. conduit (Section G). The 39th St. conduit is now practically finished, with the exception of bricking in the tunneling shields and cleaning out the work. A large pumping station, with the necessary pump wells, intakes and piers (Sections M, O and S) is now in course of construction at the foot of 39th St., east of the Illinois Central R. R. breakwater. This will pump sewage, storm water and lake water, to give the necessary flow to the Drainage Canal. The 39th St. tunnel conduit and pumping station will be described more fully below. The total length of sewer in this division will be 39,238 ft., of which 25,913 ft. were completed by the end of 1902.

It is expected that when the South Side system is put in operation, the flow through the 39th St. conduit will be about 120,000 cu. ft. per minute, making a velocity of about 6.3 ft. per second. The effect of this system will be primarily to prevent the contamination of the water supply taken from the Hyde Park intake crib of the waterworks (Eng. News, Nov. 8, 1900). It will also flush the Stock Yards slip and the South Branch of the river to its junction with the drainage canal, a condition which will be very desirable for the neighborhood, as the foul condition of the river at this point is almost beyond belief. A further advantage of this supply to the canal is that it will enable the flow through the main river to be reduced, thus facilitating navigation. It is hoped that the entire South Side division will be completed and in operation by the end of the present year.

An interesting feature of this part of the intercepting sewer system, is that with the exception of the 39th St. conduit all the work is being done by the city by day labor, under the immediate direction of Mr. F. W. Blocki, Commissioner of Public Works. The city decided upon this step after various unpleasant experiences with delays and extra cost on contracts for heavy underground work of this kind. An ordinance authorizing the construction of certain sections by day labor was passed on Jan. 31, 1900, and the results have been very satisfactory as to both progress and cost. The plant used included pile drivers

FIG. 2. DRIVING WAKEFIELD SHEET PILING FOR TRENCH OF 16-FT. SEWER.

for sheet piling, derricks handling skips and orange-peel excavating buckets, and a trench excavating machine. Fig. 2 shows the pile driver putting down Wakefield sheet piling, and Fig. 3 shows the excavating derrick at work on the trench for the 16-ft. sewer. A similar machine was also used for the back filling. Fig. 4 shows the trench bracing and the bricklaying in progress for this same sewer (Section G, noted below). On part of this work extending along the streets a trench excavating machine was used, built by the Potter Mfg. Co., of Indianapolis. This is shown in Fig. 5, and the machine was illustrated and described in full in our issue of April 28, 1898. For handling materials and removing material on this part of the work the city built about two miles of narrow gage railway along the streets, and a portion of this line, with a locomotive and train of dump cars is shown in Fig. 6. The assistant engineers in charge of the construction of the city work are Mr. W. A. Shaw and Mr. Guy Miltimore. In this connection we quote the following extract from Mr. MacHarg's report for 1901.

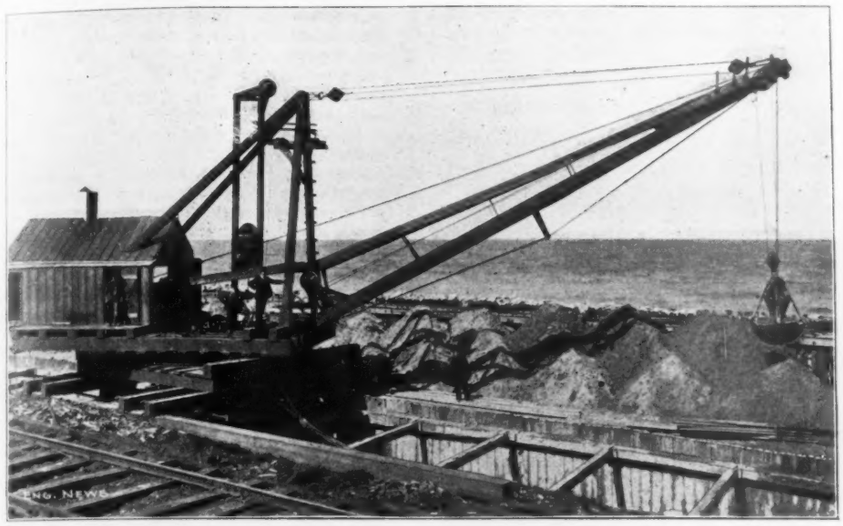

FIG. 3. SWINGING DERRICK WITH ORANGE-PEEL BUCKET.

On Jan. 3, 1901, the City Council passed an ordinance authorizing the construction of sections G and H of the intercepting sewer system by day labor. This ordinance was passed in response to a communication to the Council by Mayor Harrison, in which it was set forth that in most of the large contracts which had been entered into by the city for the construction of heavy underground work for a period of several years, the contractors had set up claims for extra compensation amounting to from 100 to 280 per cent. in addition to the original contract price, and had succeeded in obtaining these additions by litigation in case they were not otherwise allowed. At the time of this communication the contractors on Section C, intercepting sewers, were asking for a large increase in their contract price for alleged change in the structure.

Proposals had been taken for the construction of these sections by contract and these figures, together with estimates made by the department of the cost of day labor, were submitted with the communication of the Mayor. The estimates showed that the cost of construction by day labor would be about equal to the sum of the amount of the lowest bid and the cost of engineering expenses on contract work.

Work was not commenced on these sections during the year 1900, because of delays on Section C, to which this work is tributary, and it was not deemed advisable to expend this large amount of money a year before it would become useful.

On or about April 1, 1901, work was commenced on Section G, on the lake shore in the Illinois Central right of way, at the line of 39th St. produced, and just south of the location of the 39th St. conduit. Proposals were received for machinery to be used on construction, but the prices bid were very high and the city proceeded to build one pile-driver and three swinging derricks which was done at a saving of over $5,000 on the four machines as compared with the proposals.

The work on this section east of the Illinois Central railway tracks and about 50 feet inside the line of their breakwater is heavy, the bottom of the excavation being 71 feet below lake level and the cutting being 24.5 ft. below the surface of the ground. About 10 ft. depth in the bottom is stiff clay, and above this, sand, which, of course, is full of water. Wakefield sheet piling built of three 2-in. plank is used, driven to sure footing in the clay, and is left in place after the completion of the work, partly because of difficulty in drawing and partly because it affords protection to the work from the lake.

The original organization of the working force on this section was slow, because the conditions to be met by the Civil Service Commission were new. No classified lists existed in some of the mechanical divisions which occur. All men employed, however, are now on regular lists of the Commission, and the selection of excellent gangs under this system is wholly successful. The wages paid are in accordance with those paid by other employers on similar work, and the work done by each man is fully as much as is obtained anywhere.

The cost of the 2,942 ft. of 16-ft. sewer built this year is $43.88 per lineal foot, which cost includes a proportionate cost of the plant.

SECTION C.—This is the 39th St. conduit, the construction of which is described more fully below.

SECTION G.—This runs along the lake front, east of the Illinois Central R. R. tracks, from 39th St. (produced) to 56th St. and Cornell Ave. The length is 12,905 ft., of which 11,870 ft. are completed. It is 14¼ to 16 ft. diameter with five rings of brick. The work is done in open cut, by means of three traveling derricks, two with orage-peel buckets and one with skips. The work is being done by the city of Chicago by day labor.

SECTION H.—This is a continuation of Section G, on 56th St. and Jackson Park Ave., extending from Cornell Ave. to 70th St. The length is 9,550 ft., of which 2,000 ft. are completed. It is 13¼ to 13½ ft. diameter, lined with five rings of brick, and is being built in open cut by an orange-peel excavator and trench machine. The Wakefield sheet piling has been used up to date in the heavy cut. The work is being done by the city and is completed as far as 59th St.

SECTION I.—This will be built on the Illinois Central R. R. right-of-way along the lake front from 35th St. to 39th St. It will be 2,700 ft. in length, and 6½ ft. in diameter. This section is not yet under contract.

SECTION K.—This is in Jackson Park Ave. from 70th to 73d Sts., and eastward in both these streets from Jackson Park Ave. to Railroad Ave. This work will include reversing the grade of sewers in 70th and 73d Sts. so as to flow to the Jackson Park Ave. sewer instead of into the lake. The length of the main in Jackson Park Ave. will be 2,020 ft., and the diameter 12½ ft. This section is not yet under contract, and will probably be built by the city.

SECTION L.—This is an extension of the 39th St. conduit east from Lake Ave. to the lake, 460 ft. It was built by John P. Agnew, and bricklaying was completed in June, 1902.

SECTIONS M AND O.—The first of these comprises the breakwater pier and intake at the foot of 39th St., and the second comprises the pumping station at this point. The contracts for Section M and the foundations of the pumping station have been awarded to Lydon & Drews, and the work is in progress.

SECTION S.—This is the pumping plant for the above station, the contract for which has been awarded to the Allis-Chalmers Co. Further particulars of the work covered by Sections L, M, O and S are given further on.

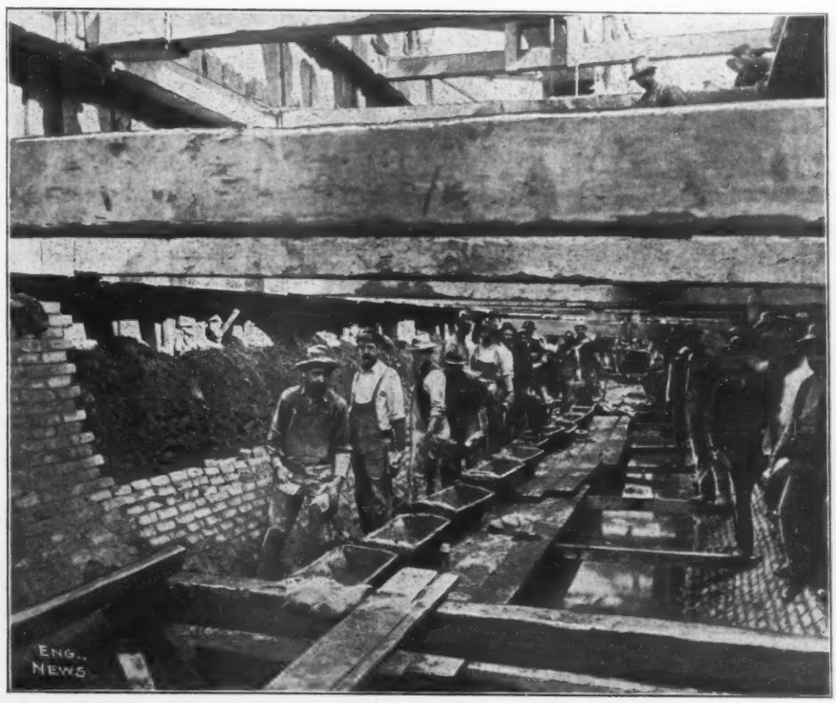

FIG. 4. BRICKLAYING IN 16-FT. SEWER.

NORTH SIDE DIVISION.

This division includes a 16-ft. conduit in Lawrence Ave. from the lake to the Chicago River, about 14,000 ft., and a north and a south arm of intercepting sewers (Secs. J, E and F). The north arm begins at Bryan Ave., near the north city

limits, and extends along the lake front to a junction with the 16-ft. conduit in Lawrence Ave., gradually enlarging to a diameter of 8 ft. The south arm extends from Surf St. on the south to Lawrence Ave., where it joins the 16-ft. conduit and is 6 ft. diameter. These arms intercept all the lateral sewers now emptying into the lake, and will, upon the completion of the system, deliver all sewage and storm water to the pumping station on the lake shore, whence it will flow (mixed with lake water) through the 16-ft. conduit to the North Branch of the Chicago River. Sections J, E and F have been finished for some time, but work on the Lawrence Ave. tunnel has been stopped by failure of the contractors, and in attempting to continue the work by day labor the city has been stopped by injunction. The pumping station was originally intended to be located near the North Branch of the Chicago River, and to have a capacity of 40,000 cu. ft. per minute. It has now been decided to locate it near the lake and to increase its pumping capacity to 80,000 cu. ft. per minute, in order to meet the requirements of the Sanitary District in regard to the flow of water in the river. Water will be pumped from the lake to the conduit, as at the 39th St. pumping station, described below. The total length of sewers in this division will be 41,538 ft. of which 32,148 ft. were completed by the end of 1902.

FIG. 5. TRENCHING MACHINE IN USE ON CHICAGO INTERCEPTING SEWERS.
(View on Cornell Ave., Looking North to Chicago Beach Hotel.)
Potter Mfg. Co., Indianapolis, Builders.

SECTION D.—This is the Lawrence Ave. conduit, the construction of which is described more fully below.

SECTION E.—This runs south in Sheridan Road from Pratt Ave. to Lawrence Ave., and is 14,569 ft. long, all of which was completed in 1898. It is 6 ft. to 8 ft. in diameter with two and three rings of brick. It was built in open cut by a steam shovel and derrick with skips. Contractors, Nash & Dowdle.

SECTION J.—This is an extension of Section E, from Pratt Ave. to Bryan Ave., 4,053 ft. It is 3¾ ft. to 5 ft. diameter, with two rings of brick. It was built in open cut by a skip derrick, and was completed in 1898. Contractors, Nash & Dowdle.

SECTION F.—This runs north in Sheridan Road from Surf St. to Lawrence Ave.; it is 8,890 ft. long, and was completed in 1898. The diameter is 4¼ to 6 ft., with two and three rings of brick. It was built in open cut by a steam shovel and a derrick with orange-peel bucket. Contractors, Cogan & Pound.

SECTION Q.—This is an extension of the Lawrence Ave. conduit, from Washtenaw Ave. to the Chicago River, 1,060 ft. It is referred to in the more complete description of the Lawrence Ave. conduit given below.

SECTION N.—This includes the breakwater pier and intake at the foot of Lawrence Ave. It is not yet under contract.

SECTIONS P AND T.—These comprise the pumping station and pumping machinery at Lawrence Ave., near the lake. The contracts for this work have not yet been let.

39TH ST. MAIN CONDUIT.

This main conduit (Section C), as already explained, will carry to the Chicago River all the sewage collected by the South Side intercepting sewers. In addition to this, however, it will form a feeder to the Drainage Canal by delivering water pumped from the lake by a special pumping plant at the foot of 39th St. This plant will have a maximum capacity of 120,000 cu. ft. per minute.

The conduit extends in a straight line west from the pumping station to the Chicago River at Halsted St. For a distance of 9,563 ft., from Lake Ave. to Butler St., it was built in tunnel, of circular section, 20 ft. in diameter, with a lining of six rings of brick. From Butler St. to the river, 21,000 ft., it was built in open cut. This portion is of flattened horseshoe section, 22 × 18½ ft., with a six-ring brick arch of 11 ft. radius, and concrete side walls and invert. The contract for this conduit was originally let to the Chicago Star Construction & Dredging Co., which company failed in April, 1900, after completing the open-cut section and 4,150 ft. of the tunnel. The open-cut section was finished in November, 1899. After considerable delay the contract for completing the work was awarded to John P. Agnew, and the tunnel was finished in December, 1902. Mr. Agnew built the first 168 ft. of his work in open cut in order to facilitate putting in the air lock, tracks, etc. An additional contract for the extension of the conduit eastward from Lake Ave. to the pumping station on the lake shore was also awarded to Mr. Agnew, and the mason work was completed in June, 1902. This section is a 20-ft. tunnel, 476 ft. long, lined with six rings of brick.

In the execution of the work, the open-cut portion was excavated by means of steam shovels and derricks with orange-peel buckets. The tunnel portions were built under the pneumatic system; the air pressure never exceeded 8½ lbs., this being the limit due to the height of water above the tunnel. In crossing under the Illinois Central R. R., however, where the depth of cover was only about 12 ft., some difficulty was experienced in maintaining the pressure, owing to the loose character of the earth. There was considerable settlement as the work progressed, and the maintenance-of-way department put stringers under the rails and kept continually lifting the track with cinder filling.

Tunneling shields were used on all this work. The Hastings shield (Eng. News, 1899, July-Dec., p. 77) was used in the construction of that portion of the tunnel built by the Chicago Star Construction & Dredging Co. Mr. Agnew, however, did not continue the use of this, but employed shields designed by his own engineers. The second shield was made somewhat stronger than the first, in accordance with suggestions made by Mr. E. C. Shankland, to whom the plans were submitted. This latter shield is shown in Figs. 7 and 8. It is 24 ft. 10 ins. diameter outside, and the forward portion, 10 ft. in length, is of 1-in. steel plate. At the middle of the 1-in. shell is an inside ring, composed of two 12-in. channels, set back to back 12 ins. apart. From the rear of this ring extend horizontal 12-in. I-beams about 15 ins. apart, forming a series of chambers for the hydraulic jacks. The rear ends of these I-beams rest upon a ring of two 12-in. channels laid side by side. The front part of the shell is stiffened by eight deep gusset plates, forming extensions of the central vertical and three horizontal partitions. There are also shallower gusset plates at the intermediate points. These plates are riveted to horizontal steel angles inside the shell and other angles against the 12-in. ring channels. The shell is divided into 16 compartments by three vertical and three horizontal partitions of ⅝-in. steel plate, each stiffened by double rows of 12-in. steel channels. The partitions do not extend to the cutting edge. Diagonal angle brackets are riveted to the vertical partitions, forming rests for stop planks to hold back loose or soft material.

The shield had 30 hydraulic jacks of 65 tons capacity each, worked by pumps capable of delivering water at 6,000 lbs. pressure. In working, about 20 tons pressure on each jack was sufficient. The 5-in. plunger of each jack had on the end a bearing plate 8 × 26 ins., butted against a circular lining of 8-in. oak timbers built within the tail of the shield, the 30 plates covering almost the entire end area of the timbering. This lining or tubbing was outside the brick lining, and was left in place. It was substituted for 1½ rings of brick lining. The piston of each jack was fitted with a ball and socket joint, so that the pressure of the jacks was distributed directly and uniformly over the face of the tubbing. The average rate of progress in 93 days in 1901 was 8.74 ft. per 24 hours. This work is in charge of Assistant Engineer R. B. Wilcox.

The first shield was of practically identical construction, but 12 ft. instead of 14 ft. long. The horizontal partitions projected nearly as far as in the shield described, but the vertical partitions

FIG. 6. TRAIN OF DUMP CARS USED BY CITY OF CHICAGO ON SEWER WORK.

did not extend beyond the vertical lines of 12-in. channels. There were only four deep gusset plates to reinforce the front part of the shell, and these extended back to the 12-in. partition channels.

According to Mr. MacHarg's report, the contract with Mr. Agnew for Section C was perfected Jan. 23, 1901, at $118 per ft., and ground was broken about April 8, but the first advance of the shield was not made until Sept. 30. On Oct. 10, the bottom of the shield was forced against a boulder and the cutting edge was buckled. Repairs were completed Oct. 24, but after one day's work a similar accident happened, and repairs were not completed until Nov. 8. No further troubles of this kind were experienced. The contract for the eastern extension of the conduit (Section L) was closed July 17, 1901, the price being $195 per ft., but there was considerable delay in the prosecution of this part of the work.

39TH ST. PUMPING STATION.

As already explained, the 39th St. conduit is planned to handle both sewage and storm water and also to serve as a feeder to the Drainage Canal, by carrying water from the lake to the Chicago River. For this purpose there is a pumping station with a capacity of 120,000 cu. ft. per minute, at the lake end of the tunnel, the State having granted the use of the submerged land for the site.

A plan of the pumping station and intake is given in Fig. 9. The intake bay is protected on two sides by a crib breakwater filled with stone, and heavily braced at the northwest angle to resist the heavy waves developed by northeast storms. On the south side, the bay is open, but its entrance is protected by a row of pile clusters as shown. The timber intake or "sand catcher" is kite-shaped in plan, 82 ft. long, 80 ft. wide at the shore end, and having a semi-circular end of 46-ft. radius. It consists of a pile framework of vertical bents connected by longitudinals. The lower panels between the bents and longitudinals are filled with concrete, while the upper panels form openings for screens 12 ft. wide, the screen being 11 ft. below datum and 9 ft. above the floor of the intake. In this way all sand and bottom dirt will be excluded. The construction of the intake is shown in Fig. 10. This timber portion is covered with a 2-in. plank roof or deck, supported by a framing of steel I-beams resting on the posts of the outer wall and on interior cast-iron columns. These columns are sheathed with 1¼-in. oak, beveled and toe-nailed, and secured by two wrappings of No. 16 copper wire. The masonry portion of the intake is roofed with I-beams and concrete arches.

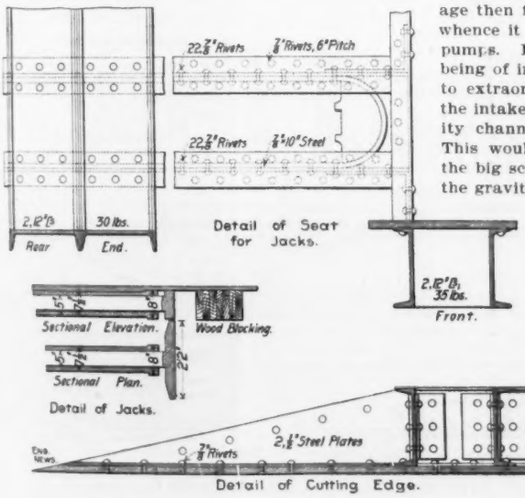

FIG. 8. DETAILS OF SHIELD.

The pumping plant will comprise two screw pumps with 14-ft. wheels, each pump having a capacity of 666 cu. ft. per second; two storm-water centrifugal pumps of 250 cu. ft. capacity, and two sewage centrifugal pumps of 75 cu. ft. capacity, or a total of 2,000 cu. ft. per minute. All these pumps are being built by the Allis-Chalmers Co. The boiler house will contain six boilers of the Babcock & Wilcox water-tube type, rated at 300 HP. each. The smokestack will be of brick, 175 ft. high, with an inside diameter of 8 ft. The building will have concrete foundations, brick walls and steel roof trusses supporting a tile roof. The screw pumps are set in an oval pump pit, 37 × 45 ft., with a lining of cast iron. The smaller centrifugal pumps have inlets 4 × 6 ft.; while the larger ones have inlets 9 × 11 ft. Sections through the pump pits and channels are given in Fig. 11. An interesting feature of this pumping station is the arrangement of pumps and channels so as to give the required flow to the river as a combination of sewage, storm water and lake water. The sewage flows into a sewage well at the south side of the station, and across the middle of this well is a gate, A. Ordinarily this gate is closed, and gate B is open, the lake water standing in the well at a higher level than the sewage and keeping gate A closed. This arrangement continues as long as the two smaller centrifugal pumps are able to handle the amount of sewage. Should this be increased beyond their capacity, the sewage will rise against the gate so as to open it against the pressure of the lake water, the sewage then flowing into the eastern end of the well, whence it is pumped by the two large centrifugal pumps. In the event of the centrifugal pumps being of insufficient capacity, owing to damage or to extraordinary flow, the gates H and J across the intake may be closed, gate D across the gravity channel closed, and gates B and C opened. This would give the sewage free flow to one of the big screw pumps. By closing gates D and E, the gravity channel may be pumped out, allowing access to the pumps. This channel used to supplement the sewerage flow by a gravity flow of the lake water, but when a greater total flow is required one or both of the screw pumps will be started. The channels for these pumps can also be closed by gates F, G and K. This work is in charge of Assistant Engineer N. A. Sager.

LAWRENCE AVE. MAIN SEWER.

This conduit (Section D) will extend in a straight line west from a pumping station at the lake to the river. It will consist of a 16-ft. sewer in open cut for 3,906 ft. at the east end (from the lake to Beacon St.) and a 16-ft. tunnel for 9,060 ft. The work in open cut was completed in November, 1899, but of the tunnel only 730 ft. are completed. The contract for the work was let originally to Farley & Green. The work has been greatly delayed, and as the contractors failed after executing the part above noted, the city undertook to complete the work by day labor, but has been stopped by an injunction from carrying out the work in this way. On other parts of the intercepting sewer system (South Side Division) the day labor method is in use, as already noted, and said to have proved eminently satisfactory. The matter of the Lawrence Ave. section has been taken to the Supreme Court by the city, and the work is in abeyance until such time as the court may pass upon the right of the city to do such work by day labor. The date of probable completion cannot therefore be stated.

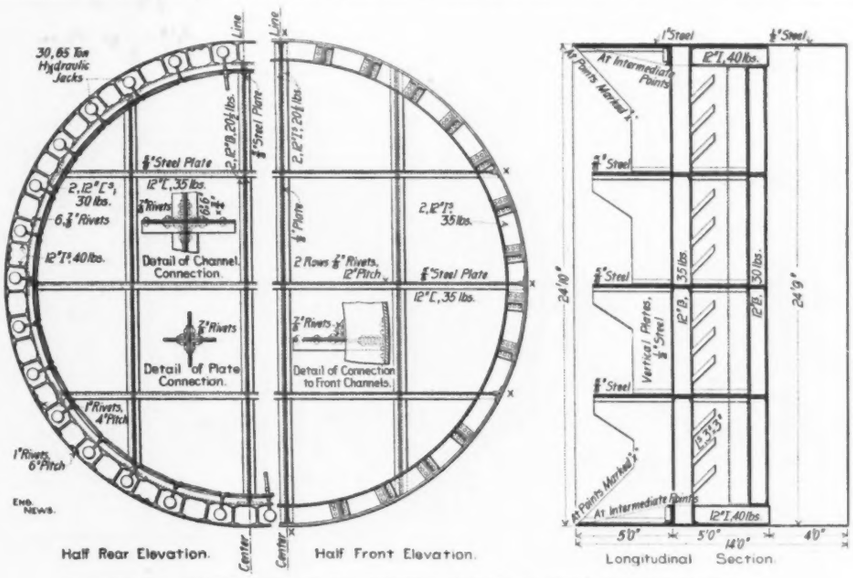

FIG. 7. SHIELD FOR 20-FT. SEWER TUNNEL IN 39TH ST., CHICAGO.

The excavation of the open-cut work was done by means of a steam shovel and a cableway. The shield used by Farley & Green was rather an excavating machine than a shield proper. It is quite complicated, and could not be made to work satisfactorily. The delays and expense incident to its use are said to have been among the causes for the financial failure of the contractors. The city will not attempt to use this form of excavating machine, but Mr. MacHarg and E. C. & R. M. Shankland have designed a shield of the Greathead type for this work in case the city is permitted to do the work by day labor. The clay through which the tunnel is to be driven is of good character, and readily supported by light timbering. No air pressure was required on the completed portion. The conduit has five rings of brick.

In addition to the 12,950 ft. of conduit in tunnel and open cut, above noted, there will be 1,060 ft. of 16-ft. conduit which the city will build in direct continuation from the end of the contract work to the river. This will be built in open cut, and will make the entire length of the conduit 14,026 ft. from the lake to the river.

LAWRENCE AVE. PUMPING STATION.

The Lawrence Ave. conduit will be not merely an intercepting sewer, but also a feeder to the Drainage Canal, by delivering water from the lake to the north branch of the river. For this purpose there will be an intake and pumping station very similar to that of the 39th St. conduit already described. The plans of the station and pumping plant are now being prepared, and the capacity will be 80,000 cu. ft. per minute.

PORTLAND CEMENT MANUFACTURED FROM BLAST-FURNACE SLAG.

In our issue of Sept. 27, 1900, we published a paper read before the British Iron and Steel Institute, and describing a process for manufacturing Portland cement from blast-furnace slag and limestone. The chief novelty of the process as described was the use of a special form of kiln for burning the raw material. The same author, The Chevalier C. de Schwarz, has recently presented a paper to the Iron and Steel Institute in which

he considers further the possibilities of Portland cement manufacture from blast-furnace slag, and discusses in an interesting manner some of the properties and qualities claimed for such cements. We abstract some of the more important parts of this paper as follows:

Portland cement of blast-furnace slag has been manufactured for several years in various cement works in Germany, Luxemburg, and in Belgium,* and has given very satisfactory results, especially as regards quality. Negotiations are at present being carried on with some blast-furnace works with a view to the introduction of the process into England, Austria, and France. In this respect a blast works has a considerable advantage over other Portland cement factories, because the motive power for the cement works could be supplied by a blast-furnace gas motor and electric transmission. Also the rubble or waste coke from the blast furnaces could be utilized in the cement kiln, and the principal raw materials, namely, the granulated slag and the limestone, are close at hand, besides other minor advantages.

Portland slag cement has also some advantages over natural Portland cement, as the yield from the raw materials with the former is about 80%, whilst when natural raw materials are used it seldom exceeds 60%. As the cost of production per ton of raw materials is nearly equal in both cases, this represents a saving of about 20% in fuel, labor, etc. Besides this, Portland slag cement is more trustworthy and more regular, and its manufacture can be more easily controlled than that of natural Portland cement, because the principal raw material, namely, the blast-furnace slag, is, as a rule, a regular product whose chemical composition is easily controlled; consequently any alterations which are liable to take place are known beforehand, and precautions can accordingly be taken in time, which is not the case with regard to the raw materials supplied by nature.

Some recent tests with Portland cement from blast-furnace slag, made in the Municipal Laboratory at Vienna, have shown that mortar composed of three parts of sand with one part of this cement gave the following results: (a) After seven days' hardening: tensile strength, 383 lbs. per sq. in.; strength of compression, 3,880 lbs. per sq. in. (b) After 28 days' hardening: tensile strength, 551 lbs. per sq. in.; strength of compression, 5,411 lbs. per sq. in.

It was remarkable that such favorable results were never obtained with any kind of Portland cement previously tested. This cement has also been accepted by the German military authorities, and it is regularly supplied to the fortifications at Metz, Coblenz, Ingolstadt, etc.; it has also been accepted by the Austrian military authorities, whilst the use of slag cement is not admitted. According to some tests made at the Imperial Laboratory in Vienna, some old pieces of beton, made in the year 1894 of one part of Portland cement of blast-furnace slag mixed with three parts of sand and as much broken up limestone, showed an average strength of compression of 4,948 lbs. per sq. in. The same concrete when tested for hardness on the emery wheel showed nearly the same degree of hardness as granite. Such beton has been declared by the military authorities to be very suitable for making bomb-proof roofings, fortifications, pavements, stairs, etc., and for this reason they are willing to pay a higher price for Portland cement of blast-furnace slag. Indeed, an eminent military authority has himself stated that for fortifications which have to resist the shock of bombs and the effects of blasting the quality of the cement is the guiding consideration for its acceptance, and not the price.

Portland cement of blast-furnace slag has also been found highly useful as an ingredient for making the so-called "verlängerter Cementmörtel." The addition of about one-sixth to one-seventh of this cement to common lime mortar promotes the induration of the latter.

It has been found that a moderate addition of granulated blast-furnace slag improves the quality of this Portland cement, besides reducing the cost of production, which

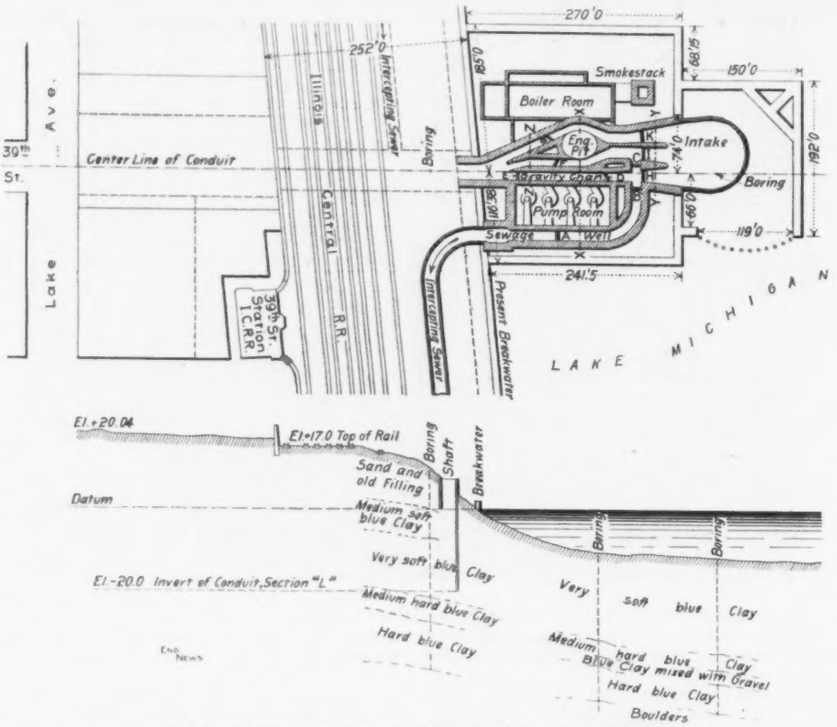

FIG. 9. PLAN OF 39TH ST. INTAKE AND PUMPING STATION.

*The total production is now about 340,000 tons per year.

third of its total contents of lime is separated as crystalline hydrate of lime, which is not only totally intact but apt to interfere with the hardening of the cement. This crystalline hydrate of lime readily combines with the free silica of the granulated slag, if such is present, and forms hydro-silicate of lime; thus not only does it render the crystalline hydrate of lime perfectly harmless, but, by making a virtue of a necessity, it increases at the same time the binding qualities of the cement.

A moderate addition of granulated blast-furnace slag to common Portland cement has, for the same reason, a beneficial influence, especially in such cases where, owing to imperfect grinding of the raw materials, or to insufficient heat in the kiln, the cement would, otherwise, be apt to "blow." Such an addition of granulated blast-furnace slag can therefore not be considered as an adulteration, as long as it takes place in quantities only just sufficient for the above-mentioned purposes. The granulated slag can be added to the cement clinker before grinding, dried but not ground; or, when ground to powder, to the finished cement, but in the latter case care must be taken that the ground slag and the ground cement are accurately determined and intimately mixed.

Granulated blast-furnace slag has a certain tendency to bind itself, which is apparent from the fact that old heaps of it have sometimes to be blasted in order to be able to remove them.

A lengthened period of storage of the clinker, at least two to three months before grinding it, is also productive of a very beneficial effect.

Further, in making Portland cement from blast-furnace slag not only the slag from grey pig iron, but also, in most cases, that from white pig iron, can advantageously be used, whilst for slag cement only the very basic slag from grey foundry pig can be employed. Experience has shown that the Portland cement made with slag from white pig iron is not only excellent in quality, but is also cheaper in manufacture, since the vitrification in the kiln takes place at a lower temperature, and sooner than when slag from grey pig iron is used, which means both a saving in fuel and an increase in the production. This fact may be attributed to the greater proportion of metallic oxides, chiefly FeO and MnO, contained in the slag from white pig iron, by which the temperature of vitrification is reduced. The presence of FeO and MnO in the cement causes an increase in the specific gravity, and at the same time renders it more suitable for buildings and structures in sea water, as will be explained later on.

Portland cement of blast-furnace slag, or Portland slag cement,* is chiefly distinguished on account os its property of increasing in hardness the older it gets, as has been proved by the following tests: A mortar composed of one part of Portland slag cement with three parts of sand showed:

After 28 days:—		
Tensile strength	350	lbs. per sq. in.
Strength of compression	2,915	" " " "
After 365 days:—		
Tensile strength	686	" " " "
Strength of compression	5,461	" " " "

Some authorized laboratory tests which were carried out in order to compare Portland slag cement with slag cement showed that a beton arch, made of one part slag cement, three parts sand, and eight parts broken stone, withstood a maximum weight of 4.46 tons per sq. yd., whilst when built of Portland slag cement in exactly the same manner it withstood 9.65 tons, or nearly double the load.

In August, 1902, Portland cement of blast-furnace slag was experimented upon at the Imperial Yaboratory in Vienna: An arch of armored concrete (System Monier), of 4¾-ft. span and 3 ft. wide, was built up of this cement, and it withstood a maximum load of nearly four tons, though only 2 ins. thick.

Slag cement is well adapted for buildings and construc-

*The German term for this product is "Eisenportland cement."

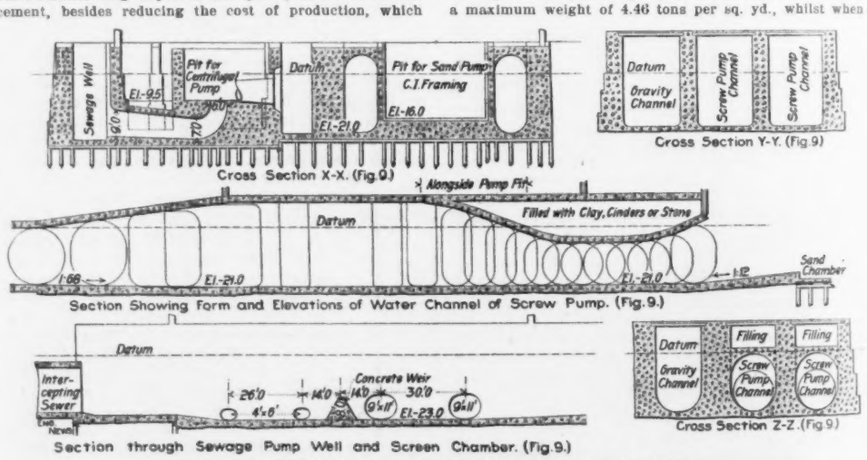

FIG. 11. SECTIONS OF CHANNELS AT PUMPING STATION.

may be explained by the fact that the free lime in the clinker enters into combination with it.

It must be mentioned that non-granulated slag cannot be used for this purpose as it does not contain any free silica, ready for combination with lime, as is the case with granulated slag, where it is formed during the process of granulation. This may be seen from the fact that non-granulated blast-furnace slag remains almost intact when treated with quicklime and water, whilst granulated slag readily combines with the lime.

When Portland cement is treated with water about one-

tions in sea water, as has been proved at Skinningrove near Saltburn-on-the-Sea, where it soon attained great hardness and strength. Also Portland slag cement has given excellent results in this direction. The use of both these cements for this particular purpose, however, is limited according to their content of alumina, which ought not to exceed a certain percentage.

The French scientist, Le Chatelier, who occupied himself with this particular question, has proved by careful study and by numerous experiments that a cement containing above 4% of active alumina, viz., alumina in such combinations as are liable to be hydrated, is decomposed by the action of the sulphates, especially by that of sulphate of magnesia contained in sea water, which causes the formation of sulphoaluminate of lime of the following composition:

$$Al_2O_3 3CaO + 3(CaOSO_3) + 30H_2O.$$

In this composition the CaO and the Al_2O_3 have been yielded by the cement, which, in consequence, is decomposed and crumbles to pieces. The same authority maintains that the presence of metallic oxides, especially that of FeO and MnO, as in slag from white pig iron, is beneficial for the purpose, as these withstand effectively the injurious influence of the sulphates, not only in sea water but in whatever form they may occur. For the same reason an addition of iron ore has also proved successful in practice, as mentioned previously. Krupp at Essen has even obtained patents for improving cement with reference to its power of resistance to the influence of sulphates, especially of those contained in sea water, by an addition of iron, manganese or chrome ore, or tap cinder, etc., to the materials used for cement making.

Mr. Henry Detienne, a Belgian authority, states that a high percentage of alumina in unburnt slag cement prolongs the time of setting, but that the contrary is the case with regard to burnt slag cement or Portland slag cement.

It is a common experience that whenever a new invention has been proved to be successful in practice the attention of those interested in the subject is roused, and attempts are made to achieve the same result, if possible, in a cheaper and simpler way. Thus soon after the results of the process, described in a previous paper* for making Portland cement of blast-furnace slag, became known, the German engineer, von Forell, took out a patent for making the same product in the following manner:

The granulated blast-furnace slag is mixed wet with broken limestone; this mixture is then ground in a pug-mill and dried in a rotating cylinder. After being dried it is ground to a fine powder in a tube-finishing mill and calcined in a rotary furnace to vitrification. This rotary furnace is heated with crushed coal, and its waste gases are utilized for drying the mixture of wet slag and limestone as it comes from the pug-mill. The clinker from the rotary calcining furnace is mixed with a certain quantity of dried slag sand and ground into fine powder, the result being Portland cement. This method is in use at some cement works in Germany and France, but it has not been widely adopted as yet, which is perhaps principally due to the fact that this process has only lately become known—that is, during a time when the cement trade was undergoing a serious crisis, and consequently while enterprise in that direction was depressed. Some difficulty may also have been experienced with the rotary calcining kiln owing to the clinker adhering to the fireproof lining, and thus causing stoppages, delay, and expense in repairs. It has already been mentioned that vitrification, that is to say, the formation of clinker, sets in quicker and at a lower temperature in the case of Portland cement made from slag, instead of with marl—as in other Portland cement factories—consequently the danger of scaffolding is greater with slag than with marl, and it is also on this account that the kilns without fireproof lining, as described formerly,* have proved successful for the manufacture of Portland cement of blast-furnace slag.

* "Journal of the Iron and Steel Institute," 1900, No. I., p. 141.

The well-known German authority, Dr. Passow, has also taken a patent, 1901, for the manufacture of Portland cement of blast-furnace slag. According to this process air is blown into the liquid slag as it comes from the blast furnace, whereby it is granulated, and it remains only to grind it into fine powder. The result of these simple operations, as Dr. Passow declares in his description, is Portland cement. He explains that the $SiO_2 2CaO$ in the slag is partly decomposed, and that, after the process of blowing, the following three combinations result:

No. I. SiO_2 2 CaO.
No. II. SiO_2 CaO + CaO, and
No. III. SiO_2 + 2 CaO.

He maintains that these three combinations, especially No. I. plus No. III., when ground gave a Portland cement cement of good quality, and that, owing to the decomposition of the slag, enough free lime is formed to render unnecessary any further addition of calcareous matter. It is understood that for this process only very basic slag from grey foundry slag can be used. This process is at present being experimented with on a large scale in Germany, and it is quite natural that the results of these operations are awaited with great attention, in some cases even with anxiety; because if it succeeds, and if "Portland cement" can really be made in such a simple and inexpensive way as described by Dr. Passow, every blast furnace producing grey pig and basic slag will become at the same time a "cement kiln," and will be able to produce Portland cement at a cost price which is perhaps less than half that of the cost of production elsewhere. In fact, it may in some cases be questionable whether the production of pig iron or the utilization of the by-products is the more important,-taking into consideration that the waste gases can be transformed into power and the slag into Portland cement.

* "Journal of the Iron and Steel Institute," 1900, No. I., p. 144.

There are also other methods for making Portland cement of blast-furnace slag, besides the above-mentioned ones, but those described here appear the most noteworthy up to date.

REDUCING BREAKAGE IN COAL SHIPPING.

Most kinds of coal suffer considerable deterioration between the time they are mined and their final utilization in the furnace. There is a certain amount of loss of heating value when coal is stored, due probably to volatilization of some of the lighter constituents of the coal. A far greater loss results from breakage in handling the coal; the larger lumps are broken up into smaller ones and a large amount of small chips and coal dust are produced. As some of this fine stuff is lost, and some of it is not used, there is a loss in quantity of coal; further, since the smaller coal makes proper firing more difficult and therefore sells at a lower price, there is a loss in quality.

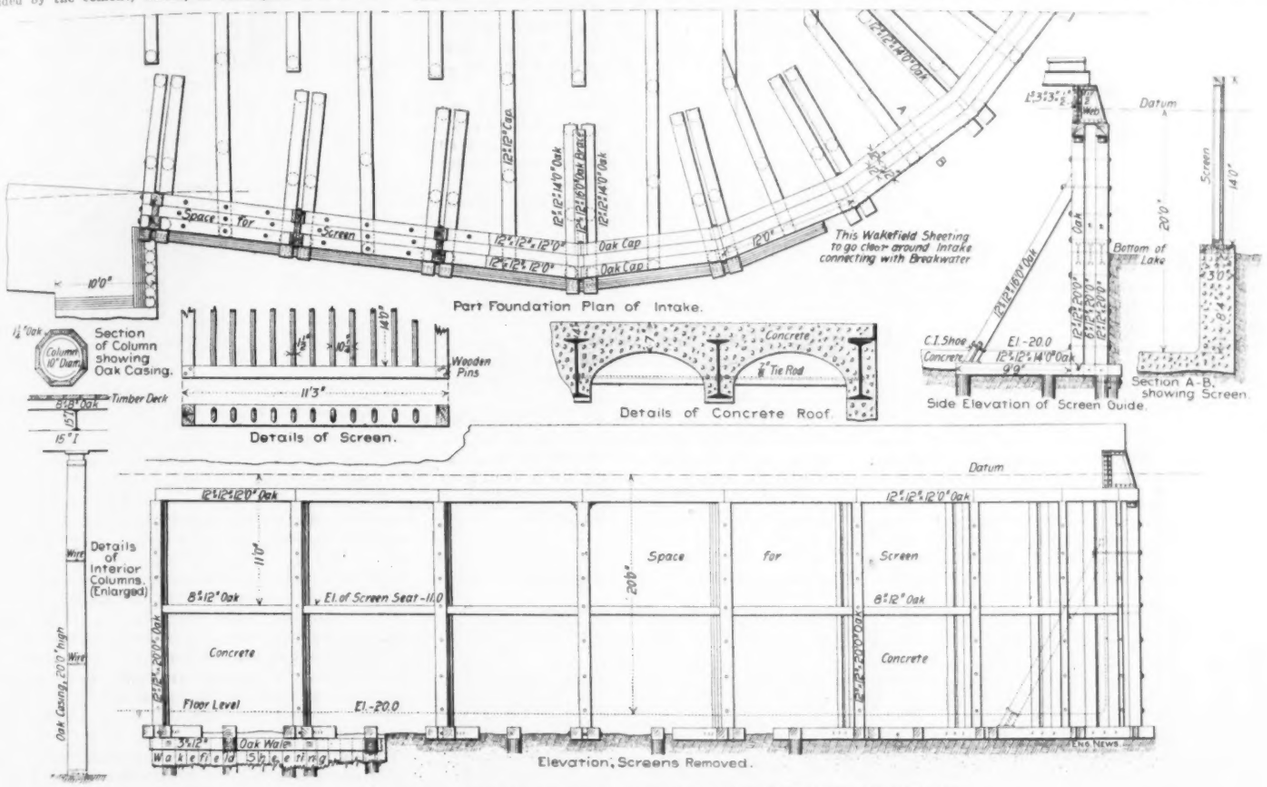

FIG. 10. DETAILS OF SCREEN CHAMBER OR SAND CATCHER AT INTAKE.

The preceding is true principally of bituminous coal, of course, since it is softer and more fragile than anthracite and contains much more volatile matter, but anthracite coal is also subject to this deterioration, though in a lesser degree. At points where coal is trans-shipped, breakage deterioration is an important matter, as it affects every ton of coal handled there and virtually increases the cost of handling the coal by the amount the coal loses in value.

On some important coal-shipping piers a new design of coal chute has recently been applied which represents an effort to reduce breakage of coal at a point where it is especially large in amount, viz., where it is loaded from railway cars into vessels. The coal reaches the piers from the mines in hopper-bottom gondola cars, and thence drops into a chute discharging through the hatchway of a vessel. On account of the greatly varying depth of hold and height of deck in different vessels, or in the same vessel in different conditions of loading, and also on account of the varying stage of the water in tidal estuaries, the chutes projecting from the pier out over the vessel must be constructed to suit the highest position of the largest ships. As a consequence, when-

ever a vessel in lower position is being loaded with coal, a considerable fall of the coal is unavoidable, and this results in a high rate of breakage even when auxiliary chutes, necessarily of steep slope, are employed. With the new type of chute, the inclined part of the chute is adjustable vertically to suit the height of vessel being loaded. Its slope is constant, and is only sufficient to allow the coal to move down; the chute is fed at its upper end from a vertical leg into which the hopper-bottom cars discharge, and a regulating gate at the upper end of the inclined portion serves to keep the vertical leg always full of coal. The coal is thus moved down the chute at a minimum velocity and with no free fall, and in this way a large part of the breakage is eliminated.

A photograph of such chutes in position on an anthracite coal-shipping pier is shown in Fig. 1, which represents one of the piers of the Philadelphia & Reading R. R. at Port Richmond, Phila. At this point large quantities of coal arriving from the company's mines in eastern Pennsylvania are transferred to vessels for marine shipment. The view shows four of the chutes, and opposite each will be seen the hopper into which the cars discharge. The vertical leg leading from this hopper is located at the edge of the pier, and on its outer face has a number of gates at different heights. The inclined chute, projecting out from the vertical leg, is adjustable in position up and down, and can be set opposite any one of the gates in the vertical leg. The chute is supported by chains, as shown, and is moved up and down by winding them on the winches above.

A development of this form of adjustable chute is shown in Fig. 2; here the vertical leg is constructed so as to virtually telescope as the chute is moved upward. The upper end of the inclined part is expanded into a receiving hopper which at all times forms the bottom of the vertical leg. An installation of forty of these chutes has lately been made at the Greenwich Point coal-shipping station of the Pennsylvania R. R., at Philadelphia. A new coal pier was erected there last year by the railroad company, and to accommodate larger vessels than the existing piers it was designed very much higher. The entire chute equipment of this pier is of the adjustable pattern shown in Fig. 2. The working of this type of chute will be readily understood from the drawing. The cut-off gate at the bottom of the main hopper may be used when it is desired to empty the vertical leg while the hopper is full of coal. This gate does not, however, serve for controlling the flow of the coal. A regulating gate for this purpose is located at the top of the inclined chute, where it serves to hold back the coal in the vertical leg, thus keeping the latter constantly full. The outer face of the vertical leg is formed of two plates, the outer one of which is fastened to the top of the inclined chute, while the inner one is fixed; these plates telescope over each other as the chute is moved up or down.

The adjustable coal chutes of both the forms described in the preceding are built by the Link-Belt Engineering Co., of Nicetown, Pa., to whom we are indebted for the originals of our illustrations.

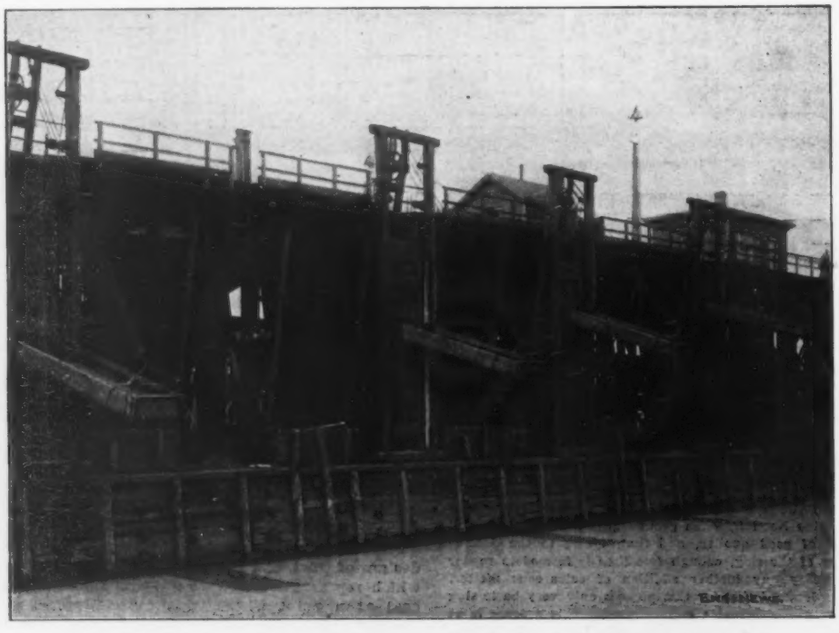

FIG. 1. ADJUSTABLE COAL CHUTES AT COAL-SHIPPING PIERS OF P. & R. R. R. CO., PHILADELPHIA, PA.
Link Belt Engineering Co., Nicetown, Pa., Builders.

TESTS OF ELECTRIC DRIVING EQUIPMENT IN THE WORKS OF THE MORDEN FROG & CROSSING CO.

By Miles F. Moore.*

About a year ago, the Morden Frog & Crossing Works of Chicago decided to increase the capacity of their plant, owing to the increased demand for their product.

In this plant rails are cut, bent and planed and made into frogs, crossings and switches for steam and street railway use. The tools and machines are of the heaviest type, and the steel worked ranges from 0.10 to 0.60 carbon. Sargeant & Lundy, of Chicago, acted as consulting engineers, and the equipment was supplied by the contractors hereinafter mentioned.

The old shop was a building 100 × 300 ft., containing all the machinery, which was driven from a line shaft 250 ft. long, by a Smith, Rankin & Beggs simple Corliss engine of 125 HP.

To extend this system to the new buildings to be erected would have involved an extension of the line shaft and numerous countershafts, as well as a larger engine.

After having carefully tested the horse-power required to drive each machine or group of machines then in service, it was decided to install an electrical equipment, as it gave more facility in the arrangement of machinery and handling of material, while cost of operation was but slightly increased.

The testing of the horse-power required to drive the various machines was accomplished by taking indicator cards from the engine. By this method there was first determined the amount of power required to drive shafting and counters without running machines. Then each machine or group of machines was tested under maximum and average running load, and from the data thus acquired the size of motors required was determined.

Having decided this point, it became a question of the best system to install. After having considered the merits of direct current and alternating current systems, it was decided to install an alternating current plant, because it was found to be equally as efficient as a direct current plant,

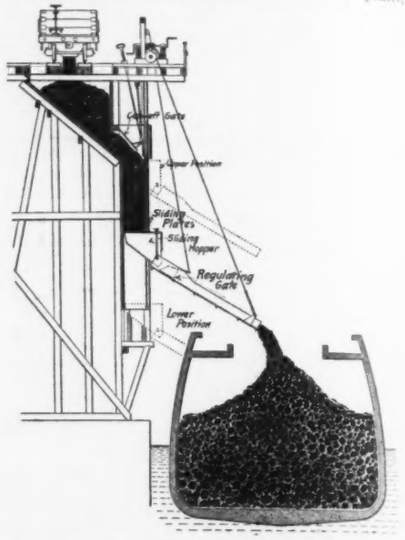

Fig. 2. Telescoping Coal Chutes of Pennsylvania R. R. at Greenwich Point, Philadelphia, Pa.

while the cost of its maintenance was almost nothing, in that there would be no commutators to keep in repair.

The plant as installed consists of two Wickes vertical water-tube boilers of 150 HP. each, a Buckeye tandem compound engine developing 300 HP. at 200 r. p. m., direct connected to a General Electric three-phase generator of 200 KW., 230-240 volts, 481 amperes, 7,200 alternations.

The switchboard was built by the Edison Co., and has one main switch of 1,000 amperes and five auxiliary switches of 200 amperes each. There is an indicating volt-meter and an indicating ammeter on the face of the board, and on the back are watt-meters for indicating total consumption of current.

In addition to the power circuits shown in the table there is a lighting circuit for 45 16-c.p. incandescent lights and 40 2,000-c.p. A and B incandescent arc lights.

In the plant there are 15 Westinghouse type "C" constant-speed motors of capacity shown in table.

This equipment has been in use for three months, and is proving very satisfactory, both in operation and in maintenance.

The load, however, is very fluctuating, and the table will no doubt give those interested in this class of work an idea of the efficiency of this kind of equipment.

The table has been carefully prepared from data taken under actual service by Mr. Ingraham, of South Chicago; Mr. Canney, of the Westinghouse Co., and the writer, and is believed by them to be correct.

In the table the column headed "Rating" is the capacity of the motor as given by the manufacturers in electrical units, while column headed "Size of motor" is manufacturers' rating in HP. The column headed "Line" shows the size of wire used in the main, while the column headed "Lead" shows the size of wire used between main and motor. The column headed "Avg. Devel. HP." shows the power consumed while working under ordinary conditions, and represents a fair working condition of the shop at all times.

In connection with this table the work done under test should be taken into consideration, and may be described as follows.

The Universal drill was tested by drilling a 1¼-in. hole through 4 ins. of soft steel in 4½ minutes.

The line shaft, which is belt-driven from two

*Engineer, Morden Frog & Crossing Works, Rookery Building, Chicago, Ill.

TEST OF ELECTRICAL EQUIPMENT AT THE MORDEN FROG & CROSSING WORKS AT SOUTH CHICAGO, Ill.

G. E. generator, 200-KW.; 481 amperes; 230-240 volts A. C.; Westinghouse type "C" constant-speed motors; 60 cycles 7,200 alt.

Size of motor.	Rating.	Line.	Size of Line.	Size of Lead.	Starting Current.	Starting Voltage.	Running Current Light.	Running Current Load.	Running Current Average.	Voltage.	Starting time.	Average HP.	Revs. per min. developed	Tools operated by motors.
5 HP.....	200 V. 15 A.	East.....	1	8	55½	90	7½	7½	7½	220	10 secs.	3.82	1,120	Radial drill, Niles universal.
20 "	" 60½ A.	East.....	1	1	163	125	22½	47½	35	220	20 "	17.84	840	14-in. pony planer, 14-in. jointer, band saw, universal saw, lathe, grindstone.
10 "	" 33½ A.	West.....	00	6	87	85	12½	27	17½	220	7 "	8.93	840	Punch, 3 single spindle drills, emery wheel.
15 "	" 42 A.	"	00	4	125	175	15	40	30	220	10 "	15.30	840	Two 15-ft. 36x36-in. Sellers planers.
5 "	" 15 A.	"	00	8	52½	100	4	8½	8½	220	10 "	4.34	1,120	Rail bender; American Bridge Works.
5 "	" 15 A.	"	00	8	52½	100	4	8½	8½	220	10 "	4.34	1,120	Rail bender; American Bridge Works.
5 "	" 15 A.	"	00	8	50	100	7½	14	11	220	5 "	5.65	1,120	Three-spindle rail drill; Newton.
7½ "	" 22½ A.	"	00	6	55	100	7½	14	11	220	10 "	5.65	840	Three-spindle rail drill; Newton.
15 "	" 42 A.	South.....	300,000	4	125	175	15	40	30	220	10 "	15.30	1,120	5-in. Beaudry hammer, 5-in. Ajax forging machine.
5 "	" 15 A.	"	300,000	8	48	100	4	14½	14½	220	7 "	7.40	1,120	Punch and shear.
20 "	" 85½ A.	"	300,000	0	220	115	65	65	65	220	15 "	33.16	850	No. 3 Root high-pressure blower; 3 lbs. pressure.
50 "	" 135 A.	"	300,000	300,000	412½	100	32½	182	145	220	40 "	74.00	850	High-speed saw, cutting 85-lb. Am. Soc. C. E. rail in 37 secs.
50 "	" 135 A.	North No. 1	00	00	450	150	50	90	70	220	25 "	71.42	850	12 switch planers, (3) 3-spindle drills, 3 milling saws, 1 punch and shear, 1 bulldozer, 1 rail bender, 5 single spindle drills, 1 bolt cutter, 1 saw grinder, 3 lathes, 4 shapers, 2 emery wheels, 1 shear.
50 "	" 135 A.	North No. 2	00	00	...	...	50	90	70	220	.....			

50-HP. motors, operated the tools shown in table, working on the class of work above described, and the test occupied a period of about one hour, the machines during this time running under ordinary service.

The benders are belt-driven by individual 5-HP. motors, and the test was the bending of a 90-lb. Am. Soc. C. E. section rail cold to an angle of 15°.

The high-speed saw is belt-driven direct from a 50-HP. motor, and the table carrying the rail is operated from the same source. The test was made by sawing through an 85-lb. rail in 40 seconds.

The blower in the smith shop operates continuously 10 to 15 hours per day, and delivers air at 3 lbs. pressure.

The pattern shop is entirely belt-driven, and during the test the machines were completely stalled without any appreciable increase in current.

With very few exceptions the machines are belt driven from motors or counters, which arrangement has been found to give the best results, as it allows for the shock due to reversal of the machines.

The testing out of these motors has been very satisfactory in that the tests show them to be of ample capacity.

This system was installed under the rules of the Department of Electricity of the city of Chicago for direct-current wiring. Under these rules the wiring is capable of taking an overload of from 35% to 50%.

It will be noticed, however, that the leads to the motors appear to be too small under these rules. As a matter of fact, they are amply large since the overload lasts but a few seconds, and, as a matter of fact, there has never been a warm wire or warm motor. The great trouble has been to get fuses of proper carrying capacity for the excessive starting current, and for the satisfactory solution of this problem there are some experiments yet to be made.

It is hoped by the writer that the table will answer some questions that all want to know, and that those who want to know more will not hesitate to make themselves known, as interchange of ideas is the royal road to knowledge.

A NEW FORM OF PHOTOMETER.

We illustrate in the accompanying sketches a new form of photometer, which has been invented by Messrs. John F. Simmance and Jacques Abady, M's. Inst. M. E., of Westminster, London, England, and which is being manufactured by Alexander Wright & Co., of Westminster. It is claimed that this device does away with many of the uncertainties which accompany tests of lights of different tints. The principle upon which it is designed and its construction and method of operation are explained as follows by the inventors:

The researches of Rood, Ferry, and Whitman from 1892 to 1896, on the subject of retinal sensitiveness to varying luminosities, more especially in respect to the retentiveness or duration of the impression of luminosities of different tints, prove conclusively that intensity is the sole arbiter of the length of such impressions and that color has no influence in the matter, and this conclusion has been confirmed by recent experiments of Simmance and Abady. This being granted it is obvious that a photometer which, taking advantage of this phenomenon, bars out all differences of color and only registers intensities, will abolish the uncertainties which have accompanied tests of various tints of light.

It is found that if rays from two sources of light, one being, for example, red and the other green, are allowed to fall in rapid succession upon a screen or upon the retina, the eye ceases to distinguish the colors, and is only sensible to the degree of intensity of the illuminations. The utilization of this fact gives us the photometer required, for if the intensities of the two lights red and green are equal, no difference in the illumination is perceptible (the eye losing all sense of colors), whereas if the intensities differ, the eye is acutely sensible of the fact.

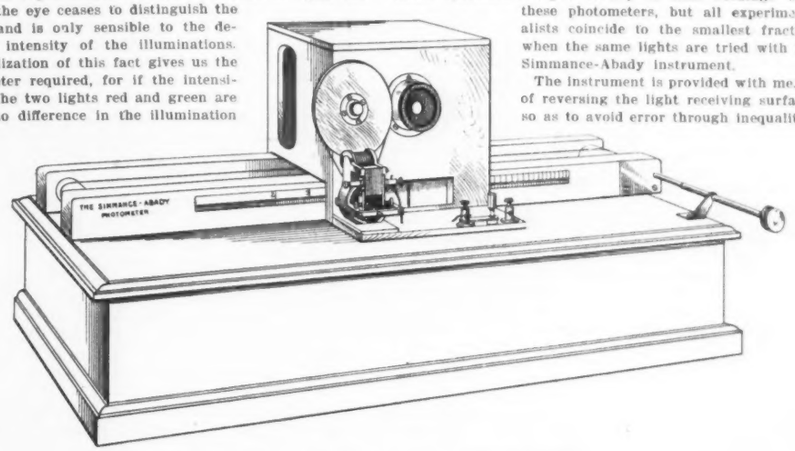

FIG. 1. THE SIMMANCE-ABADY PHOTOMETER.

The Simmance-Abady Photometer is a simple means of carrying into practice the above theory. Beams from each light (one being of a known power and the other unknown) are directed on a paper screen across which vibrates a shutter, cutting off each ray in turn. Thus the eye perceives only one ray, the source of which is each light alternately. By careful adjustment the duration of each ray is exactly the same, and the two rays do not overlap. If the lights are unequal in power the oscillation of the shutter at a given speed produces a vibrating effect, but by moving the screen and shutter nearer the weaker light a balance is gradually set up until the distances are such that rays from the two sources are equal, which point is indicated on the screen by a total absence of the vibration. Under these conditions the shutter cuts off first one ray and then the other without the eye being sensible of any movement, for although the rays may be of different colors yet the retina ceases to discern color and only judges intensity.

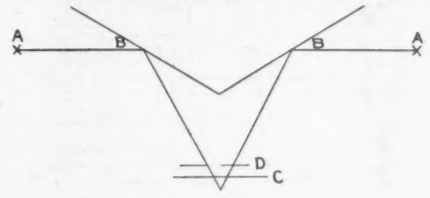

Fig. 2. Diagram Showing Principle of Operation of Simmance-Abady Photometer.

The introduction of this practical form of photometer, based on long-known laws, has enabled very accurate estimation to be made of the actual power of electric arc lamps and the incandescent gas (Auer) light. It appears probable that until now no correct estimation of their intensity has been made and the results obtained differ greatly from those to which the world has given credence hitherto.

A proof of the delicacy and unerringness of the readings by this photometer is afforded by the fact that when lights of the same color are tested by it, the results agree exactly with those made with the Bunsen or Lummer-Brodhun apparatus, whilst when the lights vary in color, different operators disagree totally in their readings with these photometers, but all experimentalists coincide to the smallest fraction when the same lights are tried with the Simmance-Abady instrument.

The instrument is provided with means of reversing the light receiving surfaces so as to avoid error through inequalities of material, and every angle and measurement is convenient for verification.

The illustration, Fig. 1, shows the complete photometer, and Fig. 2 is a diagram explaining its operation. In Fig. 2 A A are the lights, B B are the reflecting surfaces, C is the illumination screen, and D is the vibrating shutter. We are indebted to the inventors for the information from which this description has been prepared.

RAILWAY FENCING.*

By R. W. Leonard,† M. Can. Soc. C. E.

The many different kinds of fencing that one sees in common use in farming and woodland districts in Canada, where cattle are allowed to roam at large, may be estimated to cost all the way from $300 to $1,500 or more per mile, and the most expensive is not always the most efficient, durable or economical to maintain.

The continued decrease in supply of suitable timber, and the consequent increase in cost, should make this subject of keen interest to railway companies and to farm land owners.

Board fences with posts spaced about 8 ft. apart will perhaps be continued in special locations, such as through towns and close to farmers' buildings, where they are necessary to protect their smaller animals. Post and board fences will also continue to be used as a protection from snow drifts. For such purpose it is often desirable to build them much higher than for cattle protection. The writer prefers to use cedar posts, spaced 8 ft. c. to c., with the boards nailed on horizontally, breaking joints and spacing about 3 ins. apart, selecting the widest boards for the bottom. Where a fence 8 ft. high is insufficient to store the snow, it is generally better to use a temporary board hurdle fence placed back 50 or 100 ft. in the field than to increase the height.

Barbed wire has been very extensively used, but is just-

*Condensed from a paper read before the Canadian Society of Civil Engineers.

†Port Hawkesbury, N. S.

ly condemned, as being destructive to stock and inefficient unless used in combination with boards or rails, which necessitate close spacing of posts, and consequent expensive construction and maintenance. Diamond-shaped woven-wire fences and woven lath and wire fences with vertical laths are open to the same objections regarding cost and efficiency.

There are a number of different patterns of woven wire fence with horizontal wires connected by vertical wires, woven either in the factory or in the field, which possess varying degrees of excellence, and are rapidly taking the place of the other forms above mentioned. In considering the value of such fencing, the following qualities are important: (a) Efficiency in stopping horses and cattle without injury to stock or fence; (b) capability of adjusting itself to changes of temperature without unduly straining posts or wires in cold weather; (c) capability of yielding to weight of snow settling during a thaw, fallen trees, or persons climbing over it, without permanent injury; (d) liability of accommodating itself to inequalities of the ground surface; (e) low first cost; (f) low cost of maintenance.

If the horizontal wires are plain straight wires, it is necessary, in order to satisfy b, c, and d, that springs be introduced at frequent intervals, also that vertical wires be not so stiff as to remain kinked after distortion. As the cost of cedar posts and labor is continually increasing and the cost of wire generally decreasing, the fence should be of such design as to admit of wide spacing between posts, in order to satisfy e and f.

The writer has for some years used largely a fence woven in the factory, in which the horizontal steel wires are like an elongated corkscrew, with light vertical wires, and began some eight or nine years ago to space the posts 25 ft. c. to c. This distance was selected so that intermediate posts might be interpolated if demanded by the government to comply with subsidy contracts. Such intermediate posts were, however, found unnecessary, and the fences—where posts were properly set—have been eminently satisfactory, and experience has indicated that on level ground this spacing—with strong posts—could safely and economically be extended to even 50 ft. Spans should, however, be modified to suit local irregularities in the ground surface. The writer is also of opinion that true economy would be gained on a large percentage of railway fencing by limiting the number of horizontal wires to what is necessary to effectively stop cattle and horses (perhaps seven wires). In considering the effect of such long spans between posts, it must be remembered that the longer the span between fixed points the more nearly do we comply with requirements c, e, and f.

It is probable, in the writer's opinion, that the lengthened spans which will probably be used in fencing, and which demand heavier posts, may ultimately lead to the use of some form of iron post set in concrete base or some design of hollow concrete steel post when the cedar available becomes more expensive. Under present conditions, it is highly desirable to set the tension posts (at gates and corners) in a pyramidal concrete base, as the cost is low compared with the advantages gained in increased strength and durability and in preventing heaving from frost.

INVESTIGATION OF THE ARTESIAN and other underground waters of the eastern part of the country are to be carried on in 1903 by the U. S. Geological Survey in 20 different states. A recent bulletin published by the Survey gives particulars and names of the men in charge for each of the states.

THE FULL SOLUTION OF THE SEWAGE PROBLEM, AS OFFERED BY MR. SCOTT-MONCRIEFF.

Those who have followed sewage purification in England are more or less familiar with the multiple-filter-tray method tried on a small scale some years ago by Mr. W. D. Scott-Moncrieff. In brief, the aim of this method was to make successive use of the different classes of bacteria fitted for special stages of the bacterial reduction of sewage, to which end the sewage was passed through a series of filter beds, or trays, placed one above another. It appears that Mr. Scott-Moncrieff has been more or less constantly at work on this idea ever since his first installation, for the sewage of a country house. As president of the Association of Managers of Sewage Disposal Works, Mr. Scott-Moncrieff, late in March, 1903, delivered an address on "The Full Solution of the Sewage Problem," in which he reviewed his theories and studies of the subject, and stated the results thus far reached.* Passing over his claims of originality in recognizing some of the prime essentials of sewage purification, and the steps taken in reaching his present conclusions, it may be stated that the speaker's conception of the sewage disposal problem is: What means shall be adopted to make use of both the anaerobic bacteria and the aerobic, or nitrifying organisms, in such a manner as to bridge over the transition between the two main classes of bacterial life and work without clogging the final filters with fibrous and gelatinous matter? The speaker believed that he had not only solved this problem, but that his solution carried with it so high a degree of nitrification as to render the final effluent particularly valuable for sewage farming. The most difficult part of the problem pertains to the final filters, and is solved by intermittent feeding, or dosing, by means of revolving distributors, working above circular beds. The proper interval between dosing is placed "at about from 7 to 7½ minutes," whereby a nitrification "running up to as much as 15 parts per 100,000 of nitric nitrogen" has been attained, with a sewage containing about 7 parts per 100,000 of chlorine, applied "at the rate of a pint per square foot of filter surface for each feeding, or about 1 000,000 gallons (1,200,000 U. S. gallons—Ed.) per acre per 24 hours."

The speaker said he had designed a distributor, with a capacity of 300,000 (U. S.) gallons per day, two of which were then working, one at Birmingham and one at Hanley (Staffordshire).

The mechanical features of the distributor seem to have given the speaker much concern. He concluded that it would be impracticable at present to make the distributor wholly automatic in action, and described the apparatus designed, and now in use, as follows:

> The peculiar feature of this form of distributor is that the different areas to be covered at each point of the revolving radius are provided for by means of two parallel channels running from end to end of the arm, one of which acts as a continuous duct communicating at short intervals through the intervening dividing plate with the other channel, which is divided up into short sections, each having a different sized opening into the main channel, corresponding with the quantity of liquid to be delivered at each point in the radius, further provision for accurate distribution being made by means of movable weirs so adjusted as to provide accurately for equal feeding over equal areas. By this means the greatest exactness can be secured in the flow of the liquid at every point, and this is verified by the simple device of laying a shallow box, exactly 1 foot square, on any part of the surface of the filter, which receives just one pint of liquid as the distributor passes over it.

Finally, Mr. Scott-Moncrieff's general description of his "full solution of the sewage problem" may be given, as follows:

> The sewage should first be taken in a long narrow carrier, from which it escapes at right angles and at intervals about 1 yd. apart, through regulated openings, into a shallow grit chamber of the necessary dimensions to allow of the deposition of solid matter in suspension. From this grit tank it should be passed either through restricting channels, provided with gratings and upward through large stones, an arrangement known as a "cultivation tank," or through ordinary tanks, either open or covered.
>
> After having been in the grit chamber about five hours and the anaerobic tank about two hours, the raw incoming sewage should be diverted to a second set of grit chambers and tanks, and the liquid which has been longest in the anaerobic tank should then be circulated so as to pass again through the first grit chamber, to complete the hydrolysis of the suspended organic matter which will otherwise appear as sludge. This circulation of the liquid should go on until the organic sludge is reduced to a minimum. The liquid from the anaerobic tank, after having rested long enough to allow of complete liquefaction, should be passed into a distributing machine and distributed over a bed of hard filtering material of a sufficient depth, gaged to pass a ¾-in. mesh and rejected by a ¼-in. mesh, and the feeding of the effluent should be so arranged as to allow of a sufficient interval between each feeding to prevent the formation of gelatinous growths, and at the same time a sufficient quantity of air should be aspirated through the filter bed to remove the carbonic gas, and so as to provide for oxidizing the ammonia to nitric nitrogen. Finally, the effluent should be used upon land and for growing fruit and vegetables under glass. If a great part of the island of Guernsey is covered with glass on account of its climate, I see no reason why a corresponding capital should not be profitably utilized, so as to take advantage of the plant food obtainable from a highly-nitrified effluent at a sewage outfall—even though more artificial heat is required to give the best results.

*See the London "Surveyor and County Engineer," April 3, 1903, for the address in full.

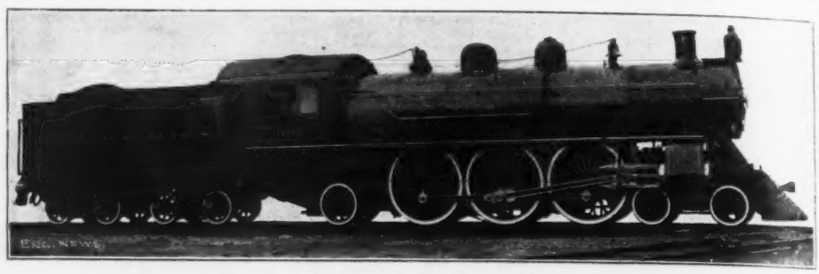

FIG. 1. PASSENGER ENGINE FOR THE CHICAGO & ALTON RY.
A. L. Humphrey, Superintendent of Motive Power.
Baldwin Locomotive Works, Philadelphia, Pa., Builders.

NEW PASSENGER LOCOMOTIVES FOR THE CHICAGO & ALTON RY.

In view of the heavy traffic between Chicago and St. Louis next year, in connection with the Louisiana Purchase Exposition at St. Louis, the Chicago & Alton Ry. intends to put in service some very powerful engines designed for making long runs with heavy trains at high speed. The special conditions require that the engine shall be capable of hauling trains of 675 tons (about 12 cars) at an average speed of 45 miles an hour. Two locomotives have been built for this service, and upon their performance will depend the final design of the rest of the engines. The two new engines are alike in all respects with the exception of the driving wheels, which are 80 ins. diameter on one engine and 73 ins. on the other. The experience in service will show which size is the best adapted to the service. The engines were built by the Baldwin Locomotive Works, of Philadelphia, Pa., to the general design of Mr. A. L. Humphrey, Superintendent of Motive Power of the Chicago & Alton Ry. We are indebted both to the builders and to Mr. Humphrey for photographs, drawings and other information.

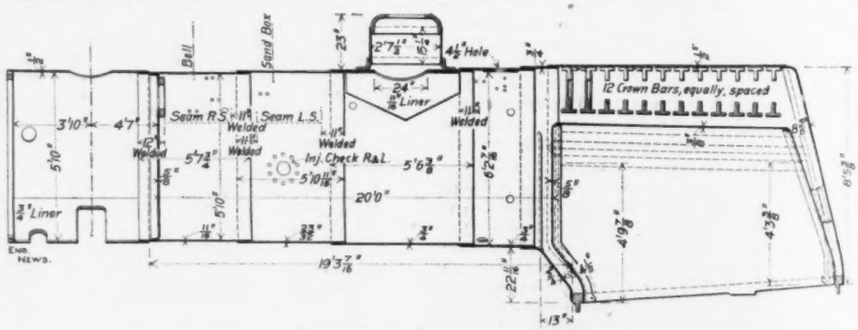

FIG. 2. BOILER OF PASSENGER ENGINE; CHICAGO & ALTON RY.

The engines are of the so-called Pacific or "4-6-2" type, having a four-wheel leading truck, six coupled driving wheels, and a two-wheel trailing truck. Fig. 1 is a general view of one of the engines, with its tender. All the wheels are flanged, but the driving wheels are placed as close together as possible, so that the rigid wheel base

is only 13 ft. 9 ins. The engine with 73-in. driving wheels has two pneumatic traction increasers, one for each truck. The cast-steel centers of these wheels are 66 ins. diameter, while those of the 80-in. wheels are 73 ins. diameter. The tender has exceptionally high sides, and is mounted on trucks having 36-in. wheels and journals 5½ × 10 ins.

The trailing truck is of the Rushton pattern, in which the axle boxes are held in a swinging cradle supported at the four top corners by pivoted links whose lower ends are secured at each side to a yoke extending either over or under the cradle. This yoke is free to move vertically, but is held laterally rigid with the frame, while the swinging of the links allows a free lateral movement to the wheels, axles and boxes. The yoke may have its own springs, but in the Chicago & Alton engines, an equalizing lever connects the rear hanger of the last driving spring with the front hanger on the yoke. The rear hanger of the yoke is connected to the end of an inverted plate spring set within the frame. A radius bar or radius frame has its forked end attached to the swinging cradle, while its forward end is pivoted

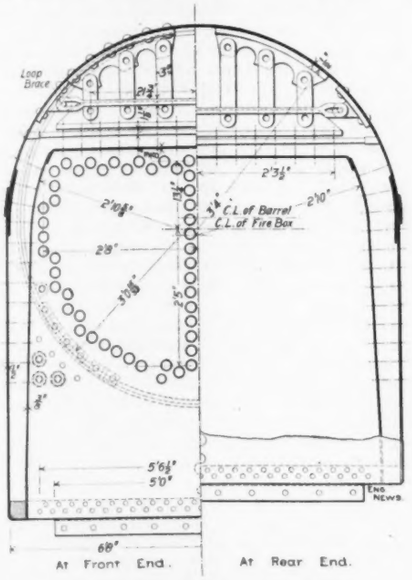

Fig. 3. Cross-Section of Firebox.

to a cross brace between the main frames, just behind the rear driving axle. This arrangement causes the truck axle to take a radial position on curves. When the engine is on a curve, the links supporting the cradle tend to raise the point of suspension, and the extra weight thus thrown upon the truck insures the return of the cradle to a central position when the engine leaves the curve for a tangent. The construction is such that the cross framing of the cradle can be kept down to about the level of the top of the axle without reducing the strength, so that a truck of this design can be placed under the rear end of an engine without interfering materially with the depth of the firebox or the arrangement of the ashpan.

The frames have double rails extending to the cylinder casting, while a short heavy rail extends from the upper rail, over the cylinder casting and down to the end of the lower rail at the bumper. The pedestal jaws are firmly held by dovetailed braces bolted to the frame. Behind the rear driving axle the frame is dropped to clear the wide firebox.

The cylinders are 22 × 28 ins., with balanced piston valves operated from rockers on the guides. The connecting and coupling rods are all of I-section and the latter have solid ends.

Ample steaming capacity is provided by the boiler, the construction of which is shown in Fig. 2. It is of the straight-top type, with the barrel 5 ft. 10 ins. to 6 ft. 2 ins. diameter and 20 ft. long. The circumferential seams are welded and double riveted; while the longitudinal seams have double-riveted outside straps and large inside liner plates. The dome is 31½ ins. diameter inside, and has its shell riveted to a flanged ring on the boiler. The dome opening in the boiler shell is 2 ft. diameter, and at this point the shell is reinforced by a heavy liner, as shown in Fig. 2. The safety valves are fitted to a 4½-in. hole behind the dome, the boiler shell being strengthened by an annular liner. The firebox is long and wide, with a flat crown sheet supported by crown bars. The back heads are inclined, giving a water space of 3½ to 8¾ ins. in width, while the front water leg is inclined to clear the rear driving axles. There are two oval fire doors 14 × 17 ins. Fig. 3 is a cross-section of the firebox. The firebrick arch is supported on four tubes.

A special feature of the engine having 73-in. driving wheels is that it is fitted with traction increasers for increasing the adhesion by transferring to the driving wheels about 12,000 lbs. of the load normally carried by the trucks. The device consists of an air cylinder operating levers which change the fulcrum of the equalizing beam and so change the distribution of weight. The arrangement of the air cylinders is shown in Fig. 4, while the details of the mechanism are shown in Fig. 5. The traction increaser connected with the front truck has an air cylinder 10 ins. diameter and 8 ins. stroke, while that for the rear truck has a cylinder 12 × 10 ins. The air reservoir supplying these cylinders is connected with the main air reservoir by means of a valve set so that it will not open with less than 90 lbs. pressure, thus preventing the use of the traction increasers from reducing the brake-reservoir pressure below a safe limit. The three-way cock which controls the application of the device, is connected with the reversing lever in such a way that when the lever is in the corner (either in full forward or backward motion), the traction increaser will be put in operation. As the lever is drawn back, however, the device is cut out and the air exhausted. A cock in the cab enables the traction increaser to be cut out altogether when desired.

These engines are the largest and heaviest ever built for passenger service. Next to them comes a Prairie (or "2-6-2") type engine built last year

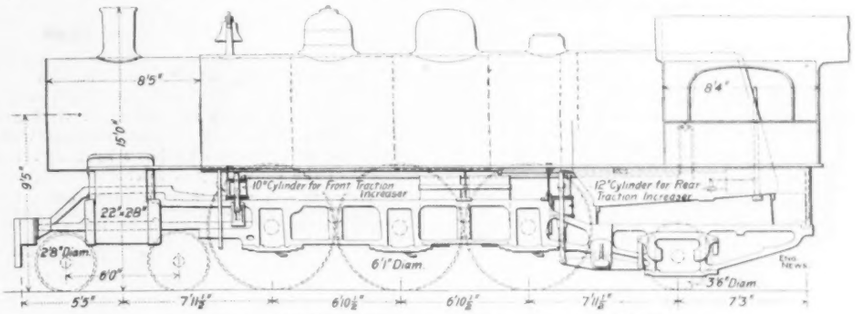

FIG. 4. ARRANGEMENT OF TRACTION INCREASERS.

by the Rogers Locomotive Works for the Illinois Central Ry., as shown by the following table:

	C. & A. Ry.	Ill. C. Ry.
Type of engine	Pacific: 4-6-2	Prairie: 2-6-2
Weight on drivers	141,700 lbs.*	144,000 lbs.
Weight, total	219,500 "	203,000 "
Driving wheels	6 ft. 8 ins.	6 ft. 3 ins.
Cylinders	22 × 28 ins.	20 × 28 ins.
Heating surface	4,078 sq. ft.	3,535 sq. ft.
Grate area	54 "	51 "

*About 153,700 lbs. with the traction increasers in operation.

The general dimensions and other particulars of these great engines for the Chicago & Alton Ry. are given below in our standard style:

New Passenger Locomotives; Chicago & Alton Ry.

RUNNING GEAR:
- Driving wheels (6)...No. 1, 6 ft. 1 in. No. 2, 6 ft. 8 ins.
- Front truck wh'ls (4).No. 1, 2 ft. 8 ins. No. 2, 3 " 0 "
- Rear truck wheels (2).....3 " 6 "
- Tender wheels (8).....3 " 0 "
- Journals, driving ..Main, 10 × 12 ins.; others, 9 × 12 ins.
- " front truck, 6½ × 13 ins.; real truck, 8 × 12 "
- " tender .....5½ × 10 "
- Driving wheel centers .....Cast steel.
- Truck and tender wheels .....Steel tired.
- Front truck..Swing center; rear truck..Rushton radial.

WHEELBASE.—Driving .....13 ft. 9 ins.
- Truck.....6 ft.; engine.....22 " 8 "
- Tender .....17 " 3 "
- Engine and tender .....62 " 0 "
- Center of truck pin to 1st driving axle..... 7 "11½"
- Wheels having blind tires.....None

WEIGHT IN WORKING ORDER.—On drivers 141,700 lbs.
- On front truck...36,300 lbs.; on rear truck.. 41,500 "
- Engine .....219,500 "
- Tender, empty....65,000 lbs.; loaded.....154,000 "
- Counterbalance, conform to M. M. Assoc. rules?....No.
- Weight of piston and rod .....560 lbs.
- " crosshead .....365 "
- " main rod—Cross-head end, 290 lbs.; main stub end, 515 lbs.; total.....508 "
- " side rods: 1st wh'l..140 lbs.; main wh'l 520 "
- " 3d wheel.....135 " ; total.....795 "

CYLINDERS (2) .....22 × 28 ins.
- Cubic contents of cylinders .....12.3 cu. ft.
- Crosshead and guides .....Alligator, two-bar.
- Connecting rod, length c. to c.....10 ft. 1¾ ins.

VALVES.....Balanced piston
- Ports....Steam 1½ × 30¾ ins.; exhaust....3 × 30¾ ins.
- Eccentrics, throw .....5 "
- Maximum travel....5¾ ins.; lead.....3-32-in.
- Steam lap.....1 in.; exhaust lap (negative),1-16-in.

BOILER.—Type ..... Straight top.
- Barrel, diam. inside smallest ring.....5 ft. 10 ins.
- barrel plates..11-16, 23-32 and ¾-in.; tube plate, ⅝-in.
- Horizontal and circular seams.....Double riveted.
- Rivets, diameter .....1, 1⅛ and 1¼ ins.
- Height, rail to center line.....9 ft. 5 ins.
- Length of smokebox (including extension).....8 " 5 "
- Smokebox arrangement, conform to M. M. rules?....No.
- Working steam pressure.....220 lbs.

FIREBOX.....Steel.
- Length inside.....9 ft; width inside.....6 ft. 0⅛ in.
- Depth, front 6 ft. 1⅝ ins.; depth at back....5 " 4⅛ ins.
- Thickness, side plates, ⅜-in.; back plate.....⅜-in.
- " crown plate ⅜-in.; tube plate.....⅝-in.
- Crown bar .....⅝ × 6 ins.
- Is firebrick arch used?.....Yes.
- Stay bolts (drilled); diameter, 1 in.; pitch about 4 ins.
- Water spaces, width, front,4½ ins.; back & sides 3½ "

TUBES.—Material....Iron; No. 11 W. G.; Number....328
- Diameter, outside .....2¼ ins.
- Length over tube plates.....20 ft.
- Total area of tube openings .....7.17 sq. ft.

HEATING SURFACE AND GRATE AREA:
- Heating surface, tubes (interior area).....3,848 sq. ft.
- " " firebox .....202 "
- " " firebrick arch tubes..... 28 "
- " " total .....4,078 "
- Grate area .....54 "
- Ratio total heating surface to grate area.....1 to 75.52
- Ratio interior tube area to firebox heat. surf..1 to 7.53
- Sq. ft. of total heat. surf. to 1 cu. ft. cyl. volume.331.54
- " firebox " " " 1 " " " .16.42
- " tube " " " 1 " " " .312.85
- Sq. ft. of grate area to 1 cu. yd. of cyl. volume.. 4.39

MISCELLANEOUS:
- Smokestack, height above rail .....15 ft.
- Capacity of tender tank .....8,400 galls.
- Capacity of coal space .....9 tons.

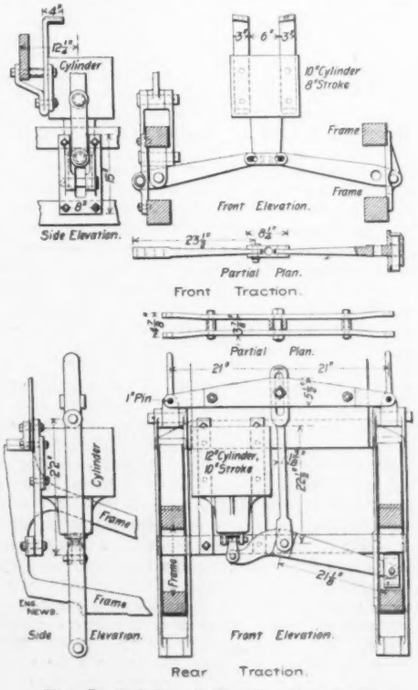

Fig. 5. Details of Traction Increasers.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

New York city is celebrating its 250th anniversary this week. While it has every reason to be proud of its growth in population, industry, and wealth, its citizens should not lose sight of the fact that notwithstanding its rapid development as a community and as a municipality, it has scarcely more than made a beginning in meeting the collective wants of its inhabitants. Much as has been done in the way of water supply, sewerage, pavements, rapid transit, tenement reform, health work, and in means of recreation for the vast masses of people in the crowded districts, New York is just on the threshold of the ideal city. To name only a few of its present deficiencies: It lacks subways for pipes and wires, without which its streets cannot be maintained in proper condition; its street sprinkling is still in the hands of private contractors, with the inevitable result that portions of the city in the greatest need of watered streets get least or none of that service; its water-works is inadequate at many points, and portions of the distribution system are antiquated; although a long period of drought would bring the city face to face with a water famine, and although it is well known that enormous quantities of water are wasted, progress in waste prevention is slow; public lighting has passed so far beyond the control of the city that the authorities claim that they are in the hands of a monopoly, and must have power to establish a municipal plant to escape from its exactions; notwithstanding the local transportation improvements now in progress much additional work of the same character is already needed. And so one might go on through a long list of other municipal wants that are either inadequately supplied or wholly neglected. It is not so much that New York is behind other cities in these respects, for municipal needs everywhere are increasing more rapidly than population. Most of these needs demand the service of the engineering and allied professions, and as both the rivalry between cities and the growth of civic spirit is bound to increase and to result in the fulfilment of these and other needs, the usefulness and dignity of the engineer and his associates, is likewise sure to increase as the years roll on.

Some suggestions relating to artesian wells which are worthy of serious consideration have been made by Prof. Israel C. Russell, of the Department of Geology, University of Michigan. In a report on "Artesian Basins in Southwestern Oregon," now in press for the U. S. Geological Survey, he makes some recommendations which have been summarized as follows by the "News-Letter" of the University of Michigan:

> In every state in which artesian basins occur, laws should be enacted prescribing that every drill-hole in an artesian basin should be properly cased, that every artesian well when not in use should be securely closed, that every abandoned drill-hole in an artesian basin should be completely filled with impervious material, and that the observance of these laws should be rigorously enforced.

Certainly natural resourses of such vital importance as are artesian waters, particularly those in the arid states, should be guarded in the interests of the public. Professor Russell also suggests that systematic public records of all wells should be kept. This, also, is a good idea, and leads us, in the absence of such records in most parts of the country, to call attention to the fact that the U. S. Geological Survey is now engaged on an extensive study of the artesian and other underground waters of the eastern and central portions of the United States. Much of its investigation is necessarily carried on by correspondence, and doubtless all of it could be furthered if those who have information on the subject for any locality would coöperate with the agents of the survey. A list of these for the several states can be secured by addressing the Hydrographic Division, U. S. Geological Survey, Washington, D. C.

Our publication two weeks ago of the official report of Mr. Wm. Pierson Judson, Deputy State Engineer of New York, on the feasibility of the Ontario route for a New York barge canal, is commented on by the New York "Evening Post," which in reply raises the plea that it is now too late to discuss the question of routes for the barge canal. We quote as follows:

> Argument at this late date on the question of route is for the most part beside the mark. Only one route is proposed by the referendum bill, and if it is not adopted, that will undoubtedly be the end of extensive canal improvement plans for a long time to come. Moreover, the route across the State outlined in the bill was determined upon by the canal advocates after the most serious and careful examination of other routes. The Lake Ontario route, which is now again being brought to the front as an argument against the modified Erie route improvements, was investigated and abandoned only when it became clear that the cost and danger of navigation for barges on the lake would destroy the efficiency of the entire canal.

Of course it is true that the voters of the State can only accept or reject the barge canal bill as a whole; but these voters have an entire right to know whether the route proposed by the bill is indeed the best that could be selected; and whether that selection was made with a view to the interests of the State at large or the pockets of the Buffalo elevator owners. What do the voters or the public know concerning this alleged "serious and careful examination of other routes," to which the "Post" refers? The fact is, as the "Post" admits, that the whole matter of route was settled by the canal advocates. In other words, a small coterie of men, many of them financially interested in the freight transfer business at New York city and Buffalo, took upon themselves the responsibility of deciding that the State had better incur an additional debt of $30,000,000 to $50,000,000 rather than choose the Ontario route for the barge canal. It seems to us that the voter, who is asked to approve this action and assume this additional burden of debt, has an interest in finding out whether these men were in fact acting for the benefit of the State's commerce, or whether they were "working for their own pockets all the time." They have informed the public that they rejected the Ontario route because it was too dangerous for the navigation of 1,000-ton barges. In contradiction of that statement we have presented an official report of Deputy State Engineer Judson, and we do not know where there could be found anywhere an expert better qualified to give an opinion upon this important point.

The "Post" says that each voter will have to decide for himself whether the State's industrial and commercial interests will be sufficiently advanced by the proposed canal to be worth the cost it is proposed to incur. That is undoubtedly true, and in forming an opinion on that point, it is certainly instructive to learn to what extent the canal was planned to benefit these interests, and to what extent it was planned to benefit the grain merchants and grain elevator owners of the cities at each terminus. The two things are not indentical by any means.

Uniform municipal accounting is making rapid progress in Ohio, thanks to the passage in May, 1902, of a legislative bill creating a "Bureau of Inspection and Supervision of Public Offices." The bill was drawn by Mr. Allen Ripley Foote, of Chicago, Editor of "Public Policy." Fortunately the new bureau secured the services of Mr. Harvey S Chase, M. Am. Soc. M. E., an experienced public accountant of Boston, who is also a member of the uniform municipal accounting committee of the National Municipal League. At the recent meeting of the organization just named Mr. Chase read a paper describing the work done in Ohio. Great care has been taken to prepare a system of accounting which, while being uniformly applicable throughout the State, will disturb as little as possible the methods previously in use. In general, the new system seems to be meeting with approval, and already the five largest cities in the State, Cleveland, Cincinnati, Columbus, Toledo, and Dayton, have nearly completed, under the new system, their final accounts for 1902. Since the law requires the annual publication of comparative statistics for the municipalities of Ohio we may hope to have soon, for the first time, a valuable collection of municipal statistics, based on fairly uniform methods of accounting and compilation. It is to be hoped that other States will speedily follow the example of Ohio. It may be added that Mr. W. D. Guilbert is State Auditor of Ohio.

In a recent issue we expressed the opinion that macadam is used far less frequently as a foundation for brick or asphalt than it should be. In last year's Report of the Paving Brick Committee of the Iowa Engineering Society, we find that macadam has been used as a foundation for brick pavements in the following nine cities and towns: Cedar Rapids, Clinton, Lyons, Ottumwa, Keokuk, Waterloo, Fort Dodge, Charles City and Muscatine. In some cases a course of brick laid flatwise was placed between the wearing course of brick and the macadam, but on several streets the wearing course of brick was laid upon 6 ins. of macadam with a cushion coat of sand between. We note, also, that in most of the streets where macadam was used, it was bound with sand, which does not always give the best of results, due largely to the tendency of the contractor to use an excess of sand in order to save on the more expensive stone. Nevertheless we find no report adverse, in so far as the sustaining quality of the macadam is concerned, although some of the streets have been in use as business streets for nine years.

One of our correspondents has written of the excellent results in Washington, D. C., where asphalt has been laid upon macadam, and we have yet to hear of a serious objection to its use.

In commenting in our last issue on the practice of securing designs by prize competitions, we remarked that the individual competitor usually has only a small chance of winning a prize, on account of the large number of competitors, and that therefore the thought and labor involved in the preparation of the designs is for the most part wasted. We considered it unnecessary to quote figures in support of this statement, but the very next number of the "Centralblatt der Bauverwaltung" (German) contains such a striking piece of

testimony on this very matter that we think it worth recording here.

In that paper are reported very briefly the results of three prize competitions, in which the award of the judges has just been announced. In the case of one of these, the number of designs entered is not stated. The second, however, a competition for plans for a school building in a city of 20,000 inhabitants, brought out 77 designs! Of these five were awarded prizes: two second prizes of 1,000-Mark ($240) each, and three third prizes of 500-Mark ($120) each. The third case is yet more striking. This was a competition for plans for a girls' high school building in a city of 15,000 inhabitants; the judges awarded one first prize of 2,000-Mark ($480), one second prize of 1,500-Mark ($360), and one third prize of 1,000-Mark ($240). The total number of designs entered in this competition was 158! These figures call for no commentary; they speak eloquently enough concerning the great losses which such competitions entail.

THE MOVEMENT FOR MUNICIPAL OWNERSHIP OF WATER-WORKS IN MAINE.

Municipal ownership of water-works in Maine is growing in favor. In 1890 there were but two publicly-owned works against 35 owned by companies. In 1893, the city of Auburn, after a hard struggle to secure legislative authority, bought the works built by a company in 1869. Since 1893, three small towns have established municipal ownership, but, according to "The Municipal Year Book" for 1902, the only places of more than 3,000 inhabitants owning their water-works were Auburn, Bangor and Lewiston. The works in Bangor were built by the city in 1875-6, and those in Lewiston were built by the city three years later. A year or more ago, agitation for municipal ownership at Waterville and Fairfield was begun. Both these places are supplied by the Maine Water Co., and finally the legislature passed an act creating the Kennebec Water District, including portions of Waterville, Fairfield, Winslow and Benton. The legality of the act was contested, but the State courts have upheld it, the people have accepted it by popular vote, and appraisers have been appointed to ascertain the value of the works of the Maine Water Co.

Acts creating other water districts have been passed, as follows:

Gardiner Water District, including parts of Gardiner, Randolph, Pittston and Farmingdale. The people have accepted the act, but appraisers have not yet been appointed.

Brunswick & Topsham Water District; bill accepted and $600 appropriated for surveys; appraisers not appointed.

Augusta Water District, including parts of Augusta, Vassalboro, and Chelsea. The city council of Augusta has endorsed the bill, but nothing further has been done. A new supply, from China Lake, or from Silver Lake and vicinity, is proposed, the lakes being 14 and 6 miles distant, respectively. The Kennebec District also proposes to draw on China Lake, 8 miles distant.

The present supply of Augusta is furnished by the Augusta Water Co.; the other places, so far as supplied, are served by three different plants, all owned by the Maine Water Co.

We are indebted to Mr. W. B. Getchell, City Engineer of Augusta, for the information given regarding the several water districts. Mr. Getchell has also sent us a copy of the act incorporating the Gardiner Water District, which we understand will serve as an example of the several acts cited. The district created is made a public corporate body, and is authorized to build works to supply the district, and "to acquire by purchase or the right of eminent domain" the plant, franchises, and privileges of the Maine Water Co. within the district. In case of failure to agree on a price for the property named, the three trustees of the water district (all, including one lawyer, to be "chosen by the municipal officers of the city of Gardiner") are authorized to take the works by means of a petition to the county court for the appointment of three disinterested appraisers. These appraisers shall "fix the valuation of said plant, property and franchises at what they are fairly and equitably worth, the valuation to be as of the date July 1, 1903." The appraisers must file their report with the court within five months of their appointment, whereupon any judge of the court "may, after notice and hearing, confirm or reject the same, or recommit it if justice requires," but the award "shall be conclusive as to values." The act provides for requests from either side to the court for "separate findings of law and fact." All findings of fact shall be final, but exceptions may be taken as to findings of law, and may be heard on appeal to a court of law.

The act provides that "all individuals, firms and corporations, whether public, private or municipal, must pay the water rates established by the trustees, which rates must be "uniform within the territory supplied by the district." The rates must be sufficient to: (1) Pay current expenses, and also "for such extensions and renewals as may become necessary;" (2) pay interest on the bonded indebtedness incurred (as this was authorized to pay for the property of the company, "and for further extensions, additions and improvements of said plant," it seems to conflict with (1).—Ed.); (3) pay 4% annually for the extinguishment of the debt. Any surplus "may be paid to the city of Gardiner." The property of the district is exempt from taxation.

The act was not to become effective unless approved by a majority of the legal voters of the whole district, and the sections authorizing the district to develop and introduce a new supply, and lay distributing mains were to be void unless the district bought the property of the Maine Water Co.

It will be seen from the foregoing outline of one of the water district acts that the interests of existing companies are well guarded by the legislature, and that, on the other hand, provision is made to prevent municipal ownership from becoming a burden on the taxpayers at large. Municipal works cannot be established until private works have been bought, and the purchase price of the latter must include "the plant, property and franchises." The appraisers' report, are subject to approval or disapproval of the court, and law questions are subject to appeal. Both public and private consumers, under municipal ownership, must pay for water used, and the rates must be sufficient to meet operating expenses, renewals and extensions, and capital charges, including in the latter 4% a year for the reduction of the debt.

The general provision for the payment for water used for public purposes is wise and just, for it ensures, if properly carried out, a fair division of the cost of water service between public and private consumers. Good judgment will be required to establish the charges for fire protection so they will be fair to all concerned, in view of the fact that while only a little water is used for this purpose the first cost of any water-works plant is greatly increased to render the works ample for the heavy but infrequent and brief drafts upon it in times of fire.

The water rates may prove to be rather high under the act, since they must be sufficient to meet extensions and provide a 4% debt-reduction fund. But the district appears to be authorized to extend the works, on purchase, as it sees fit, including the cost in the bond issue, so that by wise planning the yearly extensions may be kept low until the debt and, consequently, the capital charges have been reduced.

The outcome of this new and decided movement for municipal ownership of water-works in a state heretofore so backward in that regard will be watched with interest. However, much excitement there may have been in the agitation for or against the movement the resulting legislation seems conservative and equitable to all parties concerned.

LETTERS TO THE EDITOR.

The Design of the Buffalo Breakwater.

Sir: Referring to the description in Engineering News of March 19 of the unusual slump in the breakwater at Buffalo, my attention has been drawn to one point on which no comment has been made so far, and as the design was, in this respect, a radical departure from usual practice, it seems to me that this point is one which should be noted.

In the description of this breakwater printed in the Engineering News of May 16, 1901, it is stated:

> It is being constructed according to the design of Major Symons. It will be noted that the essential features are the gravel hearting, carried up to elev. —10 ft. . . . The top is 12 ft. above M. L. L. . . . The harbor side slope between the depth of —12 ft. and M. L. L. is 1 on .7045. . . . Had the whole structure been built of stone its cost would have been very largely increased. In formulating the design it was decided by Major Symons to use gravel for a hearting instead of rubble stone. . . . thus saving $31.32 per lineal foot by the cheaper and equally effective material.
>
> The gravel is dredged from the bed of the Niagara River. . . . The current is from 6 to 8 miles per hour. . . . It is deposited by means of dump scows between low ridges of small rubble stone dumped along the toe of the slopes.

The typical cross-section shows that this gravel core has slopes practically parallel to those of the stone work, i. e., 1 on 2½ on the outer side, and 1 on 1½ on the inner or harbor side. From the source and method of procuring, and the method of depositing, the gravel, it seems certain that its matrix must have been very thoroughly removed by the time the gravel reached its final position in the breakwater; and clean, water-washed gravel is a material with little or no coherence, and is not stable when standing at steep slopes under superimposed pressure, and subjected to repeated shocks such as this breakwater would experience from waves during a storm.

From the typical cross-section, it appears to me that the pressure on the harbor side of the hearting, due to the rubble covering and which would tend to hold the hearting in position, would be largely relieved by the concentration of pressure from the revetment wall and capping on the angle-stone at elev. —10 ft. This action would be much increased by the repeated impact of heavy seas, and at the same time the tendency of the gravel mound to flatten out would be greater on account of the increased pressure on its top and outer side due to the same cause. Under the action of these forces it does not seem unreasonable to suppose that the rubble covering of the lower part of the inner slope should have moved inward, thus allowing the hearting to flatten out and the crown of the breakwater to sink.

If this explanation of the failure is the true one, it accounts for the fact, mentioned in the letter from Mr. Hughes, printed in your issue of April 9, that the area of the typical sections above elev. —30 ft. is practically the same both before and after failure; as well as for the increase in width of base of about 30%, and the fact that the capping stones sank almost vertically and remained in contact with each other.

It is quite true, as stated in your comment on Mr. Hughes' letter, that earth *in situ* must be very soft indeed to flow like a fluid under the pressure due to the weight of a structure with so broad a base, and it seems to me far more likely that a mound of non-coherent, granular material, like gravel would settle and spread out sideways under pressure and vibration; and in this case the impact of the waves being on the lake side, the movement would naturally be toward the harbor, leaving the lake slopes practically intact.

It may be objected to this theory that the same conditions obtain in the parts of the breakwater which remain intact; but it seems to me that the silting up which has doubtless occurred in the lower part of the older portion of the breakwater would form a sufficient matrix to prevent, or at least very much impede, any movement of the gravel. Besides this, as the earth formation under the new portion seems to have been less solid than under the old, the movement in the gravel hearting may well have been started by a slight settlement of the foundation.

If this theory of the cause of the failure is correct, it would seem that there was an inherent defect in the design, in that the inner slopes were too steep, and the rubble mound at the toe, and the rubble covering on the lower slopes, were too light to allow of the use of so unstable a material as water-washed gravel for the hearting.

Very truly yours,

Thos. D. Pitts, Assoc. M. Am. Soc. C. E.

90 Halsey St., Brooklyn, N. Y., April 24, 1903.

(We referred the above letter to the U. S. Engineer office at Buffalo, with a request for comments and have received the following reply.—Ed.)

Sir: Referring to the communication of Mr. Thos. D. Pitts, Assoc. M. Am. Soc. C. E., on "The Design of the Buffalo Breakwater," it is understood that his criticism of the design aims to point out that the rubble stone and capping stone covering is liable to slide on the slopes of the gravel core or hearting, and that such sliding was especially liable to occur in the case of the Buffalo breakwater, due to the gravel being water-washed and robbed of its matrix of fine material, sand and fine gravel.

It does not seem reasonable to assume that a heavy bed of stone lying on a flat slope of gravel and primarily held in place by a heavy toe of stone at the base would be liable to an *initiative* tendency to slide because of lack of cohesion in the gravel. If the toe, or base mound, of stone is of sufficient weight to produce the required resistance to the thrust of the superimposed weight, the gravel could not slide, and it is a well-known fact that the *bearing power* of gravel is great and that it forms a good foundation under proper conditions. This is well instanced

in the case of railroad beds and embankments where gravel is always sought after and used in preference to other materials.

In the case of the Buffalo breakwater a study of the typical design will, it is believed, lead to the opinion that the structure would be stable under normal conditions of foundation—that is, *if founded upon a fairly stable bed*; and, as a matter of fact, such has been proved very emphatically to be the case in this identical structure, the Buffalo breakwater, where 6,000 ft. of the design in question has been built and has withstoood the tremendous wave force, by which it has been assailed repeatedly, for from two to five years, without a sign of settlement or disturbance of its admirable alinement.

This 6,000 ft. of structure is founded upon the clay bed of Lake Erie, reinforced by strata of sand and gravel. The borings show that the lake bed under the section of breakwater that settled is pure soft clay, entirely devoid of this sand and gravel reinforcement. This soft clay was not strong enough to counteract the weight and thrust of the structure, and the settlement, not unlooked for and fully provided for in the specifications and estimates for the work, occurred.

The cause is fully believed to have been primarily the sliding out of the toe, or base mound, on and in the soft yielding and slippery clay, and this initial disturbance, in stirring up and "puddling" the already soft clay bed and rendering it much softer, caused a vertical settlement in connection with the sliding action. It may be pointed out, in contradiction of Mr. Pitts' theory, that the gravel hearting has proved its value and bearing power in that the sliding action was more pronounced than the vertical settlement, indicating that the gravel core contributed largely to a reinforcement of the lake bed.

As a matter of fact, the successful results obtained at Buffalo in the use of the gravel core in rubble mound breakwater construction, places that design of structure in great favor; instead of in disfavor, as Mr. Pitts' comments would imply. The design not only lessens the cost, but in localities where a soft bottom is met with, the gravel strengthens the bottom and acts as a mattress to prevent excessive settlement of materials. Experience on the Buffalo construction shows that the use of gravel and sand as a reinforcement to a yielding bottom is advisable to the extent admissible without exposing such material to wave or current action.

Mr. Pitts has quoted from the description of the Buffalo breakwater, printed in the Engineering News of May 16, 1901, in an excerpted form that is very misleading: notably the excerpts relating to the dredging of gravel.

The gravel for the Buffalo breakwater was dredged in slack water along the shores of Squaw Island, near the International Bridge; not in a current of six to eight miles per hour as Mr. Pitts would interpret the original paragraph—without warrant, it may be said.

This gravel was towed up the Niagara River in scows, and in a section of the river the towing had to be done in a current of, at times, six to eight miles per hour. For this towing a tug boat of more than ordinary capacity had to be built. This is the information conveyed by the original paragraph, and while somewhat differently expressed, the original hardly warrants the excerption made by Mr. Pitts.

The gravel in the scows was frequently tested and contained from 20% to 40% of sand (sand being such material as would pass through a sieve of ¼-in. mesh). The remainder of the material was pebbles and stones up to the size of a 3-in. cube. This gravel is known to pack hard when deposited and while it is necessarily largely free from vegetable matter and light particles that might enhance its cohesive qualities, it is far from "clean water-washed gravel" composed mostly or entirely of pebbles and stones washed by a six to eight-mile current, as Mr. Pitts appears to infer. Very respectfully,

John C. Quintard, M. Am. Soc., C. E.,
Principal Assistant U. S. Engineer.

U. S. Engineer Office, 540 Federal Building,
Buffalo, N. Y., May 18, 1903.

The Effect of Forests on Flood Heights.

Sir: In your issue of April 9, 1903, in the leading editorial, discussing forestry, you make the following statement:

Briefly stated, the fact is that forests do not increase rainfall, and while they distribute the run-off from a given area over a somewhat longer period than would be occupied if the same area were cleared land, this conservation of the flow is chiefly of importance in increasing the low water flow, and not in diminishing flood heights.

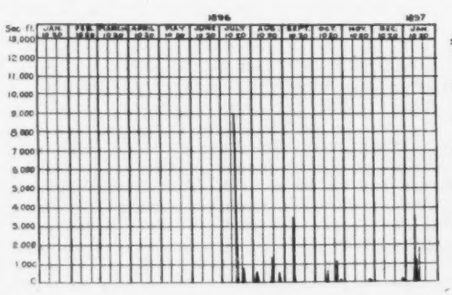
I do not understand the logic of this argument. The following data may be of interest in connection with this discussion:

"A striking example of the output of a barren, treeless drainage basin is shown in the diagram of Queen Creek, Arizona, for the year 1896. In this diagram the vertical axis indicates volumes discharged, and the horizontal axis indicates time. This stream discharges only in violent freshets, recurring usually as great flood-waves, subsiding almost as rapidly as they arise. By making from two to three current-meter measurements of each of these freshets, and keeping an hourly record of the gage height, the discharge has been approximated. The floods are usually not to exceed twelve hours in duration. During a large portion of the year the channel is nearly dry. Queen Creek rises in the mountains to the southeast of Phoenix, Ariz., and flows in a general southwesterly direction, losing itself in the desert north of the Gila River Indian Reservation. The area of the drainage basin is 143 sq. miles, of which 61% is above an elevation of 3,000 ft. and 39% below that elevation. The annual discharge is approximately 10,000 acre-ft. The basin is almost entirely bare, there being a few pinon trees and very little brush or grass. The following table of discharge for the year 1896 for Queen Creek is taken from the Eighteenth Annual Report of the Geological Survey, Part 4, Hydrography. It represents a typical year's output:

Estimated monthly discharge of Queen Creek at Whitlow's, Arizona. Drainage area 143 sq. miles.

Month, 1896.	Discharge in second-ft. Max.	Min.	Mean.
January	2	2.0	2.0
February	2	2.0	2.0
March	2	2.0	2.0
April	2	1.0	1.5
May	1	1.0	1.0
June	1	1.0	1.0
July	9,000	0.0	121.6
August	1,433	0.6	13.1
September	3,428	0.5	171.
October	1,188	0.5	13.3
November	80	0.6	1.3
December	207	0.6	2.0
Per annum	9,000	0.0	15.0

"In contrast with Queen Creek in Arizona, a diagram is given showing the discharge of Cedar Creek, Washington, for the year 1897. The point of measurement of this stream is at Clifford's bridge, in section 19, town 22 north, range 7 east, Willamette Meridian. The drainage area is estimated to be 143 sq. miles, and it therefore is the same as the area of the basin of Queen Creek. The basin of Cedar Creek lies on the western slope of the Cascade mountains. It is heavily timbered, and in addition the ground is covered with a very heavy growth of ferns and moss. The precipitation for the year 1897 was about 93 inches in the lower portion of the basin, and is estimated



Discharge of Queen Creek, at Whitlow's Ranch, Arizona, 1896-97.

to have been as great as 150 inches on the mountain summits. The rainfall of the Queen Creek basin is estimated to be about 15 ins. The maximum flood discharge in 1896 on Queen Creek was 9,000 cu. ft. per second, and the maximum discharge of Cedar Creek in 1897 was 3,601 cu. ft. per second. The mean discharge for Queen Creek was 15 cu. ft. per second, and for Cedar Creek 1,089 cu. ft. per second. While Queen Creek is frequently dry, the minimum discharge of Cedar Creek during the period in question was never less than 27% of the mean for the year. These two streams represent extreme types. The radical difference in their character is believed to be largely due to the difference in forest cover. The discharge of Cedar Creek for the year 1897 is believed to be fairly representative. The following table of discharge is taken from the Nineteenth Annual Report of the Geological Survey, Part 4, Hydrography:"

Estimated monthly discharge of Cedar Creek near Seattle, Washington. Drainage area, 143 sq. miles.

Month, 1897.	Discharge in second-ft. Max.	Min.	Mean
January	2,812	815	1,430
February	2,415	823	1,303
March	1,366	723	901
April	2,752	790	1,562
May	2,143	939	1,562
June	1,410	780	1,060
July	2,284	572	1,135
August	561	342	427
September	418	311	350
October	433	294	339
November	3,155	323	1,318
December	3,601	674	1,639
Per annum	3,601	294	1,089

It will be noted that the vertical scale showing the discharge is twice as large on the Cedar Creek diagram as on that of Queen Creek. If they were on the same scale the contrast would be greater.

Queen Creek, in Arizona, being from a treeless drainage basin, carries excessive amounts of silt. Cedar Creek is a clear stream. Yours very truly,

J. B. Lippincott.

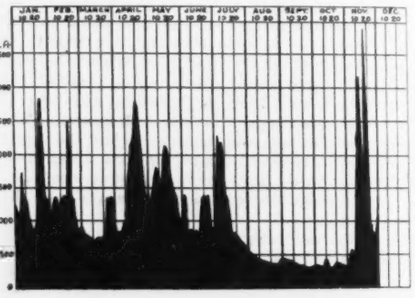
Los Angeles, Cal., May 7, 1903.

(Our correspondent's comparison is certainly a most interesting one. We freely admit that our statement which he quotes would not apply to streams in an arid region. As to streams in a humid region, we may explain the logic on which our statement was based as follows:

The maximum flood flow from a drainage basin in a humid region is produced as a rule either by rain falling at a time when the ground is heavily covered with snow or by a heavy rainfall occurring at a time when the ground is already saturated from previous rains. When rain falls under such conditions, the rate of run-off, we believe, will be about the same whether the country is covered by forest or not.

Of course it may be said that even when rain falls on saturated ground the run-off will be more rapid from a hard barren desert tract than from a region covered with primeval forest growth, such as that in the Cascade Mountains above described. But such a comparison is not a fair one. We are discussing, it must be remembered, the effect of forestry on stream run-off, and any fair comparison must be made between forest tracts and cleared tracts in the same region. Take, for example, such floods as those which occurred in West Virginia and North Carolina in the summer of 1901 (described in Engineering News of Aug. 7, 1902). A large part of the area subjected to these floods is heavily forested; yet the streams rose so suddenly as to cause great destruction of property and even the loss of lives. It is difficult to believe that the floods could have been much more severe had the land on which the rain fell been generally cleared.

Of course theoretically it may be argued that the run-off from a forested region, even in floods,



Discharge of Cedar River, Near Seattle, Washington, 1897.

is distributed over a longer time, and so the flood height is less. The practical point on which we endeavored to lay stress, however, remains true: that the effect of a forest cover on the flow from a drainage area "is chiefly of importance in increasing the low water flow and not in diminishing flood heights." Extreme floods occur, as every one knows, on rivers which drain a heavily forested region, and even though their height may be somewhat diminished because of the retardation of the run-off, it can hardly be claimed that forestation is a practical remedy for floods.

On the other hand, the forest cover is of very great practical importance in maintaining the low water flow of streams, as the diagrams furnished by our correspondent give ample evidence.

Finally, we may note that the editorial to which our correspondent refers in our issue of April 9 related principally to the floods in great rivers like the Ohio and Mississippi, and not to the flow in small streams such as those cited by our correspondent. In these great rivers the flood wave is of such duration that the retarding effect of forest cover on the basins supplying the rivers affects its maximum height very little.—Ed.)

The Union Engineering Society House.

Sir: If not too late, I beg to transmit herewith my reply to your letter of the 8th inst., concerning the Engineering Building, which it is proposed to erect in the city of New York.

It was only by dint of much conscientious and painstaking work on the part of men usually busy with professional cares, that the American Society of Civil Engineers has, during its existence of over fifty years, built

up a representative membership, the lowering of whose standard in any possible degree would be a distinct loss to the engineering profession. The material force and vitality of the Society is demonstrated, moreover, by the fact that it owns, practically free of debt, a handsome home valued at several hundred thousand dollars. It is only natural, therefore, that the proposed association with Engineering Societies of more recent origin, involved in the acceptance of Mr. Carnegie's splendid offer, should be viewed by a large proportion of the membership of the American Society of Civil Engineers with some concern.

It is quite clear, however, that the profession has been brought by Mr. Carnegie's offer face to face with an actual condition calling for prompt and decisive action. I, for one, am of the opinion that the same spirit which has elevated the American Society of Civil Engineers to its present high position, will be amply able to maintain and preserve its individuality, even if housed under the same roof with organizations, whose standard of membership, like our own, must improve from year to year, as a prerequisite of their very existence.

It is fair to all the engineering societies to expect, however, that the Union Building be planned to enable each organization to preserve its distinctive characteristics to the fullest extent. A modern office building contains interests diversified to an almost unlimited extent, while business rivals are not unfrequently found on adjoining floors. There should in consequence be no difficulty in suitably allotting the floor space in the proposed building in such a manner that each organization may carry on its own work in the most advantageous manner, and in its own way.

With best wishes for the success of the project, I remain, very truly yours,

J. V. W. Reynders.

Steelton, Pa., May 19, 1903.

The Union Engineering Building Project.

Sir: At the solicitation of a number of representative members of the American Society of Civil Engineers with whom I have corresponded or conferred regarding the proposition which has been suddenly urged, that the Society should immediately reverse its long-established policy and enter into a business partnership with three other technical societies and a social club in the joint ownership and occupation of a building to be erected in whole or in part with funds contributed by Mr. Andrew Carnegie, on land to be purchased by the affiliated organizations, I ask your publication of the views which many members entertain on the subject, as I understand them.

The idea of having all Engineering Societies under one roof is not a new one. It has been discussed for about twenty-five years. Within that period a number of organizations have been founded by specialists in various branches of engineering, who have not been willing to limit their aspirations for control or for prominence of the specialty to which they were devoted, by submission to the restriction imposed by the American Society of Civil Engineers, in which no specialty of engineering practice is given a predominance.

That Society having attained a standing and a prestige as a National ONrganization of broad scope, many members of the other societies of specialists, who either could not or would not join the American Society of Civil Engineers, have naturally been desirous that some affiliation with that Society should be effected, which would place their own organization on a par with the older one in the estimation of the general public.

The idea of a common house and library for all has been the usual one brought forward. Some members of the American Society of Civil Engineers have long advocated the erection by the Society of a house large enough to accommodate other associations also. One of the obstacles to carrying out this idea has been the difficulty of providing for the financial security of an enterprise involving so great an expenditure, for the accommodation of parties of variable and uncertain resources and untried methods of management.

The present proposition originated thus:

In an after-dinner speech on the occasion of the founding of the Library of the Institute of Electrical Engineers, of which I cannot find any notice in Engineering News, but which is stated to have occurred on February 9th last, Mr. Scott, the President of the Institute, dwelt upon the desirability of a building which should be the home of all Engineering Societies. Mr. Carnegie, who was present, was struck with the idea and the next day expressed to Mr. Scott his willingness to aid in carrying it out. Mr. Scott consulted hurriedly with a few members of the various societies and also some members of the Engineers' Club, which is not a technical association in any sense, except in name, and is known chiefly as a convenient meeting place for engineers, contractors and sales agents. The attention of Mr. Scott and the other conferees was called to the fact that the American Society of Civil Engineers had several times refused to entertain such a proposition, but the majority of those consulted thought the scheme might be worked out, and they so informed Mr. Carnegie on Feb. 14th, and he thereupon wrote a letter offering to give to the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers and the Engineers' Club, one million dollars towards the erection of "a suitable Union Building for them all."

Stringent obligations of secrecy were imposed on the dozen persons who were cognizant of this offer, until options could be secured on property adjoining the site which the Engineers' Club had selected for a home, so that it was not until May 3d that any intimation whatever was given even to the members of the Board of Direction of the American Society of Civil Engineers, that it was proposed to involve the Society in a speculation requiring the expenditure of nearly two million dollars. I have been a member of that Board for two years and a half and have attended every meeting, and thought that I was pretty well acquainted with the Society's affairs and policy, but I knew nothing whatever of this scheme until I saw in the daily newspapers of May 4 that Mr. Carnegie had made this gift and the A. S. C. E. was going to accept it, and the next day I received by mail a printed pamphlet marked "confidential," in which an elaborate project was outlined for a partnership of the parties concerned and the directors of the various societies were requested to attend a meeting on May 7 at the A. S. C. E. House to ratify the proposition, and to accept the gift for all alike. That meeting was held as proposed and as a matter of self-protection some of our directors were present and prevented the passage of an elaborate set of resolutions put forward by the promoters and substituted for them a simple vote of thank to Mr. Carnegie for his generous offer.

A few days later, the governing boards of three of the societies affected formally accepted the proposition and asked for a committee of conference. The American Society of Civil Engineers not being a monarchy, or under one-man rule; nor an oligarchy, or under clique rule; but a pure democracy in which the majority rules, the Board of Directors have no authority to reverse its well-established policy without a referendum, but thought it best, at an informal meeting held May 13, at which 13 members were present, to request a committee of three to attend the meeting of the conference committee asked for, in order to try and find out what the promoters had to suggest in the way of a division of the expense of the purchase of land, amounting to over half a million dollars, arrangement and management of the building, et, cetera, in case the A. S. C. E. should conclude to go into the partnership. That was all they had any authority to do in the matter. The conference committee does not appear to have had any ideas to suggest, notwithstanding their having undertaken an enormous trust involving difficult questions of law, of finance and of policy. They only asked that the several societies named in the offer should go it blind, accept the offer and settle the details afterwards, instead of giving them something definite to vote upon before accepting or refusing.

Inasmuch as this matter will probably be considerably discussed at the Asheville Convention of the A. S. C. E. on June 9, it behooves the members of the A. S. C. E. to carefully consider the question in all its bearings and give time for reflection before voting. There is no hurry about it, for Mr. Carnegie has said that the declination of his offer by one of the organizations would not affect his offer of a Union Building to the others.

In common with many members whom I have consulted, I think that the old-established policy of the American Society of Civil Engineers should be upheld unless some very strong arguments can be brought forward in support of a reversal of that policy.

That policy may, I think, be thus stated:

The Society is not an educational institution nor a commercial exchange, but an association of men who have acquired such an education and practical training in any branch of Civil Engineering as to warrant their being classed as members of a Profession and not simply as expert mechanics or skilful tradesmen. Juniors and Associates are affiliated with them, but not on a membership basis, and they have no voice in the management of the Society. Full membership of the Society is intended to carry with it, so far as is practicable in any such organization, a guarantee of the mental, moral and practical fitness of a man to be ranked as a Professional Civil Engineer.

It is not consistent with the aims and purposes of this Society for it to become associated with other associations having a lower standard of membership, in such a way as to lead either the members of such organizations or the general public to assume that all the persons so associated stand on the same professional plane.

While it is unquestionably true that there are in the various other engineering societies, many members who rank as high professionally as any members of the American Society of Civil Engineers, and about two hundred and fifty of them are also members of the A. S. C. E., the only reason for the existence of the other societies is that there have been and always will be, a good many men who feel the need of an Association, but are either unable or unwilling to comply with the requirements of the American Society of Civil Engineers as to full membership and who prefer to be members only of such an organization as will accord to them the privileges of the highest grade of membership and participation in the control of the organization.

The American Society of Civil Engineers has never been disposed to engage in any such business or professional alliance with such societies as would lead to a general impression of the equality of the professional standing of all the parties to the alliance.

It is now proposed that the American Society of Civil Engineers shall unite with other technical societies and also with an unprofessional social and commercial organization, in the acceptance of a gift of a Union Building for them all. In the deed of gift all the societies are grouped as co-ordinate and equal. In the scheme of co-operation proposed by the promoters of the project, all the recipients of the gift of a house are designated as "tenants in common, share and share alike." The libraries are proposed to be merged in one and the auditoriums are to be used by all alike. The purchase of the land on which the building is to stand is to be shared in by all. I cannot believe that such a merging of the individuality of the Society is desirable.

Leaving out of account the moral considerations which have heretofore influenced the action of the American Society of Civil Engineers and considering only the business features of the proposed merger, it appears that the American Society of Civil Engineers owns and occupies a commodious house built for its use, which has cost about $250,000 and on which there is a mortgage of $55,000, which is being rapidly paid off from current receipts. It also has a library of over 40,000 volumes, valued at $50,000. The Mechanical Engineers own property valued at $80,000. The Mining Engineers own no property, have a small library and say they do not want a building. The Electrical Engineers own no property, but have a building fund of $30,000 and have begun a library. The Engineers' Club own no property and have no library worth mentioning.

Here then is one successful corporation which has both cash and credit and has shown its ability to manage a large and growing business. It is asked to go blindly into a partnership with four other concerns which so far have not displayed their ability in that line, in the purchase of half a million dollars worth of land and the control of a million-dollar house. The instant that it accepts the proposition it is at the mercy of the majority of the holders of the interest. Its own property must be sacrificed and the proceeds put into a speculation in which they will be liable to confiscation to meet a possible deficit of payment of interest by one or more of the partners who will be obliged to make a heavy loan on the property in order to get into it at all.

The proposition to create this partnership has not proceeded from the party which has cash and credit, but from others who have little, but who are striving to produce the impression that it is essential to the prosperity of the engineering profession that the partnership should be consummated immediately without any opportunity being given for the adjustment of an equitable basis of control of the property beforehand.

If the majority of the members of hte American Society of Civil Engineers want to go into the partnership, well and good. But they ought to be given a chance to think over the pros and cons.

J. J. R. Croes.

68 Broad St., New York City, May 25, 1903.

(In commenting on the Union Engineering Building project, two weeks ago, we urged the members of the American Society of Civil Engineers to consider the matter without prejudice and with regard to the future of the profession rather than the past. We have the same thought in mind as we read what Mr. Croes has to say above concerning the events of 25 years ago. There is doubtless plenty of unwritten history concerning the rivalries and heart-burnings and jealousies which have prevailed in the past between different organizations of engineers—or rather between the few controlling spirits in these organizations—but is it wise or profitable or beneficial to the profession to bring these matters into prominence at the present day? We believe that the profession has outgrown these things, and that among the members of the American Society of Civil Engineers in general there is no disposition to claim any superiority for one branch of the profession over another.

As for claiming precedence for the Civil Engineers' Society as an institution of broader scope than the other societies, we should face facts and not theories. Notwithstanding the broad significance of the term "civil engineer," as originally coined, at the present day "civil engineering" has come to be a distinct branch of the profession, and the American Society of Civil Engineers has come to represent this branch and not the entire range of engineering work. This has come about in the natural order of events; and in the same way organizations of engineers devoted to other

branches of the profession have grown up, and have become great, strong, widely known and influential.

Mr. Croes says:

> The only reason for the existence of the other societies is that there have been and always will be a good many men who feel the need of an Association; but are either unable or unwilling to comply with the requirements of the American Society of Civil Engineers as to full membership.

If this theory of Mr. Croes is true, there is absolutely no need of the societies devoted to mechanical engineering, mining engineering, electrical engineering, naval architecture, railway engineering, testing materials, engineering education and so on through a long list. The many thousands of engineers belonging to these various societies have joined them only because, forsooth, they were unable to obtain admission as "full members" to the American Society of Civil Engineers! We need not say how far removed such an idea is from the actual state of affairs. Such an idea wholly ignores and overlooks the vast development and specialization which has taken place in the engineering profession during the past half-century. When the engineers' sole work was the building of canals and railways, one society of engineers was comprehensive enough to embrace the whole profession; but those are the conditions of half a century ago.

Again Mr. Croes says:

> It is not consistent with the aims and purpose of this Society for it to become associated with other associations having a lower standard of membership in such a way as to lead either the members of such organizations or the general public to assume that all the persons so associated stand on the same professional plane. . . . I cannot believe that such a merging of the individuality of the Society is desirable.

Again we must repeat our appeal that the matter should be considered without prejudice. The proposition before the societies is not affiliation or merger of the several societies in any sense. Each will be exactly as free to carry on its own business in its own way and to maintain its own standards as it is at the present time. There is no proposition for union or consolidation. All that is proposed is coöperation in the ownership and occupation of a great building. As for the fear expressed that the general public will confuse the different societies and will imagine that all "stand on the same professional plane," it is difficult for us to take such an objection seriously. What does the general public, or even that portion of the general public which employs engineers, know or care about the intricacies of the rules for admission of members to the various societies? What layman knows even the difference between a "Full Member" and an "Associate Member," or an "Associate" or a "Fellow," in the American Society of Civil Engineers? These fine distinctions are well enough, perhaps, inside the profession; but let us not get an exaggerated idea of their importance.

Turning now to Mr. Croes' comparison of the financial status of the several societies, it seems to us that this argument loses its potency, when it is recalled that through Mr. Carnegies generosity, the financial problems in connection with the proposed coöperation have been reduced to very small proportions. The American Society of Civil Engineers owes its present house and library largely to the generous contributions of wealthy members. Now comes forward Mr. Carnegie, a member of the Mining and Mechanical Engineering Societies, and offers to build a million-dollar building for all the societies. Is it exactly fitting under such conditions for the American Society of Civil Engineers to emphasize its own wealth and prosperity as compared with its sister societies? Particularly when the fact is that each of these societies is likely to be able to bear its full share of the financial responsibility in connection with the proposed land purchase without difficulty.

We might say much more in answer to Mr. Croes' arguments; but time and space forbid. This much, however, must be said: If the prevailing temper of the American Society of Civil Engineers toward its sister societies were correctly represented by Mr. Croes, there would be most emphatic dissent in all these societies at anything in the way of coöperation with the Civil Engineers. These societies have made and can make their own reputation without help from any other organization, and have no desire whatever to shine by borrowed light.

We are very glad to beleve that the sentiments of the above letter are not held by any considerable proportion of the Civil Engineers' membership, and in proof of this assertion we may cite the numerous letters from leading members of the Society printed in our last two issues, presenting an overwhelming opinion in favor of the proposed coöperation and expressing in the highest degree sentiments of hearty good will and fraternity toward the other organizations of engineers. —Ed.)

Notes and Queries.

F. D. H., Los Angeles, Cal., writes:

Will you kindly advise me through the columns of your paper if The Master Car Builders' Association has adopted any standard for minimum clearance above top of rail, for the nuts of column bolts in car-truck construction; if so, what is such minimum clearance? If no minimum clearance has been adopted, will you tell me the minimum clearance in general use.

We find no standard for this dimension in the list of M. C. B. standards. In any ordinary type of truck with 33-in. wheels there is no object in bringing the column bolts far enough down to be in danger of hitting anything. In the 80,000-lb. gondola car of the Chicago & Alton Ry., illustrated in our issue of Feb. 26, the clearance is about 7 ins.

H. A. S. wishes references to tests of concrete-steel or of large-sized cement pipe under 50 to 75 lbs. pressure.

There appears to be very little published information on the subject. We shall be glad to have our attention called to other references besides the following:

Tests of Joints in Vitrified Sewer Pipes. By M. A. Howe. Eng. News, 1892, II.—252, 256; 1895, I.—12, 19, 26.

Tests of Vitrified Water Pipe at Peoria, Ill. By D. H. Maury, Jr. Eng. News, 1896, I.—341.

European Methods of Testing Cement and Clay Pipes. Eng. News, 1898, II.—151.

Test of Concrete and Expanded Metal Conduit for Jersey City Water Supply. Eng. News, 1900, II.—142.

A correspondent has some indicator diagrams from a compound engine. He has plotted these so as to bring the high-pressure card in its proper theoretical position with regard to the low-pressure card, the front and rear ends of the cylinders being plotted side by side instead of superposed. The high-pressure cylinder develops 800 I. HP., while the low-pressure indicates 850. He asks whether each of the high-pressure cards should be marked 800 I. HP. and each of the low-pressure cards 850 I. HP., or whether the figures 400 and 425 I. HP. should be used.

The cards from front and rear end of each cylinder are usually superposed in such diagrams, and there is then no need for the above question. However, the two ends of a cylinder for various reasons may not be doing equal amounts of work, and to emphasize this fact the power developed in each end may be stated separately. In this case it would be proper to put an explanatory note on the diagram, stating the total power developed in each cylinder and also the total power developed by the engine.

G. E. L. asks the following:

We note a remark by Mr. Santos Dumont, in relation to motors for propelling his airship, that the weight of such motors had been reduced to 6 lbs. per I. HP. Can you give us the address of parties building these motors for any purpose? Are there any such in America? We presume Dumont was speaking of gasoline motors, and it is this type of motor we refer to.

We do not believe that motors anywhere near as light as this are built for the market. We do not know who built the engine of Mr. Santos Dumont. For special experiments motors have been built in America of extreme lightness, but we believe that the figure of 6 lbs. per I. HP. has not been reached in the past. Perhaps some of our readers can give information on this subject.

In our report of the beginning of a triangulation of New York city, on page 466, 457, of our last issue, one or two errors were made. The following corrects these and presents some additional information:

The existing work of triangulation in New York city comprises a complete triangulation of the borough of the Bronx, made some years ago, and in addition some measurements of angles between stations in some of the other boroughs. With the exception of that done in the Bronx, this work cannot be used as part of the present triangulation. As the apparatus and methods used on the Bronx triangulation differ from those used on the Coast & Geodetic Survey, the value of that work as part of the comprehensive triangulation now being carried out will be determined later, and for the present the Bronx will not be included in the network. The steps leading up to the actual beginning of the present work were as follows: The new charter of Greater New York re-enacted the provision of the original charter that a triangulation of the city was to be made under an engineer experienced in practice surveying and qualified by a civil service examination, with the amendment that the direction of the work was transferred from the Commissioner of Public Works to the Presidents of the several boroughs. About a year ago it occurred to Mr. Nelson P. Lewis, Engineer of the Board of Estimate and Apportionment, that it would be highly desirable to have the assistance of the U. S. Coast & Geodetic Survey in the triangulation, and after some correspondence with Superintendent Tittmann of that Survey a provisional agreement was drawn up by the latter, as a basis for such co-operation. In order to enable the city to take advantage of this plan, an amendment to the charter was passed at the last session of the legislature of New York State, and became operative about three weeks ago when the Governor signed the measure. The Board of Estimate and Apportionment at once converted the provisional agreement with the Survey into a contract, and the latter delegated Mr. Mosman as Director of the triangulation. As we related in our article on the work, Mr. Mosman has already established an office (189 Montague St., Brooklyn,) as headquarters for the work, and it is expected that a large part of the primary network will have been observed by the end of the present season. The remainder of the work comprises fixing and determining secondary points at intervals of 5,000 to 10,000 ft. over the whole of Brooklyn, Queens and Richmond and the upper portion of Manhattan boroughs. The computation of the spherical co-ordinates (latitude, longitude, azimuth of connecting lines) of all these points will be supplemented by calculating the rectangular co-ordinates of each point from some fixed origin in each borough, on true medidians and parallels passing through that origin.

THE UNION HOME FOR ENGINEERS.*

From the time when Mr. Carnegie's offer of the money wherewith to build a common home was made known to the five engineering societies in this city, it seemed probable that at least three would eagerly accept. About the others, there was room for doubt. The mining engineers are not incorporated, and it has been understood that they did not want to be. The obstacle to such a step is merely technical and can easily be overcome. Entirely unforeseen circumstances have arisen, and will undoubtedly lead that body to look at the question in a new light.

The civil engineers had a fine new building of their own, to which they had become attached, and they were naturally reluctant to change. Moreover, a local periodical which might be supposed to represent them discredited the idea of co-operation, and thought that not one vote out of ten in the society would be cast in its favor. From the editorial attitude of another periodical, "Engineering News," it quickly became evident that in some quarters the project was warmly favored. From the tenor of letters from subscribers in last week's issue of "Engineering News," moreover, it would seem that about five civil eugineers approve the idea to one who is opposed. Thus, the outlook has distinctly improved in the last three weeks.

The question of accepting or declining Mr. Carnegie's proposition will be, and ought to be, settled only by the men to whom it was addressed. They are entirely competent to judge what is for their own interests. Nevertheless, the outside world cannot help forming opinions of its own. Affiliation, which involves no sacrifice of independence, is of unquestionable advantage in such organizations as the American and British Associations for the Advancement of Science. Sciences which are distictly different in name and apparently dissimilar in aim are often related in certain particulars. How much closer is the bond between the branches of one profession! When the Pennsylvania Railroad Company decided to establish a terminal in this city and adopt a new system of traction, it found that it needed the advice of men familiar with the latest advances in civil, mechanical, mining and electrical engineering. Is this instance unique? Will there not always be a need for co-operation between individual representatives of these departments of knowledge and between the associations to which they belong?

A LARGE GAS ENGINE PLANT is to be built for the Velardena Mining & Smelting Co. of Velardena (Durango), Mexico. This plant will comprise gas engines aggregating 2,000 HP., operating from a central power station an ore concentrating mill, pumps and hoists at six of the company's mines, located within a radius of 10 miles. This plant will be built by the new Loomis-Pettibone Gas Machinery Co. of New York, which also has contracts for gas engine plants driving electric generators; one of these is a 1,200-HP. plant for the Rockland Electric Co., Hillburn, N. Y., and the other for the Potosina Electric Co. of San Luis Potosi, Mexico. The company states that it is producing power with a consumption of 2½ lbs. of wood or 1 lb. of good bituminous coal per brake HP. per hour.

HIGH STEAM ECONOMY was shown in tests recently made on an English engine by Prof. J. A. Ewing. The engine is a tandem compound of 300 HP., built by Easton & Co., of Erith, England. It had poppet valves on the high-pressure and Corliss valves on the low-pressure cylinder. A reheating receiver was located between the two

*From the New York "Tribune," May 25.

cylinders and was heated by the live steam passing to the high-pressure cylinder. The boiler furnished steam at 150 lbs. pressure, but before going to the engine this passed through an independently-fired superheater which raised its temperature to about 800° F. The temperature of the steam arriving at the engine was about 580° F., about 170° having been lost in the reheater. The exhaust from the low-pressure cylinder went to a jet condenser. The steam consumption was taken at different loads, a dynamo being direct-connected to the engine. The weight of steam was found from the feed-water supplied, while indicators were used to give the power of the engine. The results obtained are as follows:

Trial No.	I. HP.	Effective electrical output KW.	E.HP.	Ratio of E.HP. to I.HP.	No. of lbs of steam. Total per hour.	Per I.HP. hour.	Per electric unit.
1.....	312	190	255	.82	2,925	9.4	15.4
3.....	239	143	192	.80	2,150	9.0	15.0
2.....	175	97	130	.74	1,670	9.5	17.2
4.....	47	3.5	4.8	..	975	..	...

The coal consumption was about 1.41 lbs. of coal per indicated horse-power per hour. The indicated power at no load was about 28 HP., and the dynamo running on open circuit, but with full excitation consumed 14 HP. more. The dynamo loss at full load was about 29 HP. The condenser was operated from the tail-rod of the engine; the feed-pump was a separately steam-driven unit, and its steam consumption is not included in the figures given. At 140 lbs. pressure, the 9 lbs. of steam, superheated to 800° F., correspond, in heat contained, to about 10.4 lbs. saturated steam of the same pressure. No economizer was used, and the boiler was worked to about half capacity only, so that the figure for coal consumption might be lowered.

MOTOR CAR MANUFACTURE in Great Britain is thus commented on by Mr. William Wier in a paper recently read before the Scottish Automobile Club:

The present position of the industry in this country appears to be that we are able to build about 2,500 cars per annum of many different patterns, and that we import about 3,500 cars per annum. Next, that in the design of our cars we have practically nothing to learn from our competitors, as it has been demonstrated repeatedly that we can now build good, reliable and serviceable cars. Next, that with very few exceptions, none of our manufacturing concerns have up to the present made any considerable profit on the sale of their cars.

MUNICIPAL CIVIL SERVICE EXAMINATIONS have their bad as well as their good features, as is shown by facts recently brought out in New York, and reported in the "Engineering Review" for April. Two young men who had gone through college and law school together, believing that any well-educated man could easily pass many civil service examinations by a little cramming and some coaching from practical men, acted accordingly and took some eight different civil service examinations in succession. They were classed among the first five in most or all of the examinations taken. Among other places, one of these young men was made eligible for the position of district superintendent of street cleaning, in competition with 560 applicants. The position pays $1,800 a year, besides which a horse, carriage and assistant are provided. One of the young men was recently notified that he stood next on the eligible list of plumbing inspectors, and was asked to report for duty.

ESTIMATES FOR AN ELECTRIC PLANT FOR PUBLIC LIGHTING IN NEW YORK CITY.

Estimates of the cost of building and operating a plant to furnish 10,000 arc and 160,000 incandescent electric lamps for lighting the streets, public buildings and places of the boroughs of Manhattan and the Bronx, New York city, have been completed by Mr. Cary T. Hutchinson, M. Inst. E. E., of 56 Pine St., New York city. In transmitting this report to Mayor Low, Mr. Robert Grier Monroe, Commissioner of Water Supply, Gas and Electricity, refers to his report of March 13 (see Eng. News, March 19), in which he presented figures showing that other American cities were paying an average of $88.60 per 2,000 c. p. arc lamp, as compared with the $146 bid for Manhattan and the Bronx, and (approximately) $125 for other parts of New York. Mr. Monroe again recommends that the bids received early this year for both gas and electric lighting be rejected. He also recommends that the city advertise for bids for mantle gas lights, stating that in Manhattan the city has the right to gas for public lighting at the rate of 90 cts. per 1,000 cu. ft.

Mr. Hutchinson's report is here given substantially in full:

GENERAL CONDITIONS.—There are now in Manhattan 3,155 arc lamps and in the Bronx 1,822—a total for the two boroughs of 4,977. This number is insufficient—particularly for Manhattan. There should be at least twice as many in Manhattan; 10,000 is the minimum now required, and more would be better.

The city now pays for lighting about 600 public buildings and places, such as markets, parks, school houses, police stations, engine houses, hospitals, repair shops and yards, public baths, etc.; about half of this lighting is by gas, the rest by electricity. All of this lighting should be electric; the equivalent connected capacity of all this public lighting is about 160,000 16-c. p. electric lights; in the near future large extensions of this lighting will be required. There is no satisfactory way to estimate the future requirements; hence central station capacity has been provided only sufficient for all the present lighting of public buildings and places by electricity, eliminating gas entirely. The central station capacity can easily be increased as the demand increases.

The conditions in Manhattan and in the Bronx are very different. In Manhattan all circuits must be underground and the distribution of lighting is relatively dense. In the Bronx the problem is more that of a suburban town; all wires are overhead and the density of the distribution is low.

In order to get a close approximation to the distributing system required, every arc light now in use in the two boroughs was plotted on a map of large scale; sub-stations were placed at suitable points and the length of the circuits measured; similarly for the incandescent lighting—each building or public place now lighted by the city was plotted on the map, with the number of lights connected; a distributing system was then laid out to provide for the lights. This information was obtained by actual counting of all lights in some 600 places.

SYSTEM.—For street lighting I recommend the use of 7.5 ampere, inclosed, series, alternating-current arc lamps; for lighting public buildings and places, an alternating-current system. The central station capacity to supply 10,000 480-watt arc lamps and 160,000 16-c. p. incandescent lamps will be 10,000 KW.

The system will comprise a power station located at some convenient point, with generators supplying current to a transmission system consisting of high-pressure feeders placed underground and terminating in sub-stations, from which will radiate the distributing circuits for the arc and incandescent lights. The length of the high-pressure feeders has been measured from the eastern side of Blackwell's Island. The precise location of this station is largely immaterial, the chief points of importance being good facilities for coal and water. The feeder lengths will be less than estimated for any other probable site. Blackwell's Island has the additional advantage of permitting easy access to Brooklyn.

In Manhattan there willl be five sub-stations principally for the arc-lighting circuits, but providing also for that part of the incandescent lights within reasonable distance. These sub-stations will all be connected to the central station by duplicate 10,000-volt feeders, placed underground in ducts. The incandescent lighting is so scattered that it cannot be economically provided for from these sub-stations; branch feeders at 10,000 volts will run from the sub-stations and terminate in transformers placed in certain of the buildings now lighted by the city. The buildings so selected will then become centers of distribution and from them will radiate the low-pressure lighting circuits. The high-pressure branch feeders will terminate in brick inclosures in which oil-insulated transformers will be placed.

For the Bronx, a somewhat different system must be used, on account of the greater distance apart of the buildings to be lighted and the great cost of an underground system; a sub-station will be placed near the Harlem River, where the pressure will be changed to 3,500 volts, and from this sub-station 3,500-volt, three-phase feeders will run overhead to centers of distribution placed either in public buildings, as on Manhattan, or on tops of poles; the 3,500-volt feeders will also supply the constant current transformers at the three sub-stations from which the arc-lighting circuits radiate.

This system, with one type of generator and transmission circuit for both kinds of lighting, is the simplest that can be used; it will be easy to adapt it to any improved methods of lighting; in particular, it permits the use of Nernst lamps in the public buildings.

CENTRAL STATION.—The central station will be equipped with three-phase, 60-cycle generators, having a combined capacity of 10,000 KW. at a power factor of 80%—6,000 KW. for arc and 4,000 for incandescent lighting.

The estimates of the cost of this station are made for machinery of the best character, including water-tube boilers of an aggregate capacity of 10,000 boiler HP., equipped with coal and ash-handling machinery, stokers, economizers, superheaters and all accessories; and vertical, cross-compound, condensing engines of the Corliss type, each direct-connected to 60-cycle, three-phase, 80-revolution, 10,000-volt generators. There will also be direct-driven exciters, the usual switchboards and auxiliaries. The total rated capacity of the generators will be 10,000 KW., but their overload capacity is ample to supply this power with one unit out of service, and there will be ample reserve in the boiler plant to operate with one battery out of service.

The estimate includes engines of the Corliss type. The use of steam turbines would reduce the cost of construction by some $200,000, and should be seriously considered before the plan is finally decided upon.

REAL ESTATE.—In the estimate of the cost of the central station no charge is made for real estate. The best site for this station is on the eastern side of Blackwell's Island, where the property is owned by the city and is not in use; but if this site cannot be secured, the city owns a block front on the East River well located for this purpose, which is valued at $45,000, and now is rented at $40 per month.

TABLE I.—Cost of Central Station.

Boiler plant complete, having a capacity of 10,000 boiler HP., with coal and ash-handling machinery, economizers, superheaters, piping and foundations, ready for operation.....	$500,000
Vertical engine plant erected complete, with condensers, foundations and piping.....	325,000
Electric generating plant having a capacity of 10,000 KW., erected complete, including generators, exciters, switchboards and all auxiliaries	300,000
Excavation and building	250,000
Total	$1,375,000

This is equal to $137.50 per KW.; it is higher than the cost of either the Manhattan or Rapid Transit stations.

SUB-STATIONS.—In Manhattan there will be five sub-stations, supplied at 10,000 volts, and providing for all arc and some incandescent lighting. There will also be about fifty centers of distribution for incandescent lighting alone. The arc lighting has been laid out in circuits of approximately fifty lights, with a maximum voltage of 4,500.

In the Bronx there will be a principal sub-station where all energy will be transformed to 3,500 volts, three sub-stations for arc lighting, and about twenty centers of distribution for the incandescent circuits; the incandescent lights in all cases will be supplied from a 240-volt, three-wire, alternating-current system.

The lighting in the Bronx is only about 20% of the total for the two boroughs; hence the double transformation is a matter of minor importance. In the future, when the number of lights in the Bronx becomes greater, it will be a simple matter to change over to a 10,000-volt underground system. The number of motors in service is so small that it is not worth taking into account in this general estimate.

COST OF PLANT.—The total cost of the plant for supplying 7,000 arc lights in Manhattan, 3,000 in the Bronx, 125,000 incandescent light connections in Manhattan and 25,000 in the Bronx, is given in Table II.

TABLE II.—Cost of Plant.

1.	Power plant, as above.....	$1,375,000
2.	High-pressure feeders	260,000
3.	3,500-volt feeders, in the Bronx.....	40,000
4.	Distributing circuits for incandescent light'g	90,000
5.	12,000-light capacity constant current transformers...	120,000
6.	7,500-KW. capacity constant potential transformers.....	75,000
7.	Switchboards in sub-station	75,000
8.	Arc light cable, Manhattan	540,000
9.	Arc light circuits, Bronx	50,000
10.	Centers of distribution, structures only....	50,000
11.	Arc light poles, Manhattan and Bronx.....	345,000
12.	Arc lamps and fixtures	250,000
13.	Distribution poles for Bronx	150,000
14.	Five buildings in Manhattan for sub-stations	100,000
15.	Four buildings in Bronx for sub-stations....	50,000
16.	Real estate in Manhattan	95,000
17.	Real estate in Bronx	20,000
18.	Engineering and contingencies.....	370,000
19.	Interest during construction	143,000
	Total $4,208,000	

Item 1—Is given in detail in Table I.

Item 2—Is calculated from distances measured from the eastern side of Blackwell's Island.

Items 3 and 4—Are determined from measured distances.

Item 5—Is based on estimates submitted by manufacturers.

Item 6—Is determined by fixing the capacity of the separate centers of distribution. Several of these centers will have transformers of medium size, but the majority will be small; the minimum capacity has been kept at about 10 KW.

Item 7—Is an estimate submitted by a manufacturer.

Items 8 and 9—Are determined by measured lengths of all circuits.

Item 10—Is based on the assumption that each center will be practically a bricked vault.

Item 11—Includes 9,000 poles at $30 apiece, similiar to the poles used in Boston, and 1,000 at $75 apiece.

Item 12—Is an estimate submitted by a manufacturer.

Item 13—Is determined by the measured length of circuits.

Item 14—Is an estimate for one-story buildings for sub-stations.

Item 15—Is an estimate for smaller and simpler buildings for the Bronx.

Item 16—Is the value of real estate as appraised by an expert for lots at the points required.

Item 17—Is similarly determined.

Item 18—Is an arbitrary allowance of 10% for engineering and contingencies.

Item 19—Is interest at the rate of 3.5% for one year, on the assumption that the average period during which the investment will be unproductive will be one year.

DIVISION OF COSTS.—Table III. gives the division of the total cost between the arc and incandescent service. This division is made on the basis of 60% for arc and 40% for incandescent, of all those items in Table III. that are directly dependent upon the power used. It is assumed that 6,000 KW. is used for the arc and 4,000 KW. for the incandescent lighting; the maximum power required for the incandescent lighting will probably be less than 4,000 KW., but this amount is allowed. The total energy required for incandescent lighting can, however,

be estimated closely. The other items are apportioned on the basis of the actual requirements.

TABLE III.—Division of Costs.

	Arc.	Incandescent.
1. Power plant, as above	$825,000	$550,000
2. High-pressure feeders	120,000	140,000
3. 3,500 volt feeders in The Bronx	25,000	25,000
4. Distributing circuits for incandescent lighting	.....	90,000
5. 12,000-light capacity constant current transformers	120,000	.....
6. 7,500 KW. capacity constant potential transformers	.....	75,000
7. Switchboards in sub-stations	50,000	25,000
8. Arc light cable, Manhattan	540,000	.....
9. Arc light circuits, Bronx	50,000	.....
10. Centers of distribution, structure only	.....	50,000
11. Arc light poles, Manhattan and Bronx	345,000	.....
12. Arc lamps and fixtures	250,000	.....
13. Distribution poles for Bronx	120,000	30,000
14. Five buildings in Manhattan for sub-stations	75,000	25,000
15. Four buildings in Bronx for sub-stations	35,000	15,000
16. Real estate in Manhattan	70,000	25,000
17. Real estate in Bronx	15,000	5,000
18. Engineering and contingencies	264,000	100,000
19. Interest during construction	102,000	41,000
Grand total	$3,006,000	$1,202,000
Total per arc lamp		$300.60
Total per KW. of station capacity for incandescent lighting		300.50

The total cost of a plant having a capacity to supply 5,000 arc lights and the present lighting of public buildings will be $3,000,000, of which $1,800,000 should be apportioned to the arc lighting service and $1,200,000 to the incandescent service.

DUCTS.—In the above tables of costs no allowance is made for the cost of ducts; I have been instructed to omit this item of cost, and have been informed by city authorities that the city has the right, under its contract with the Subway Co., to use the subway free of rental.

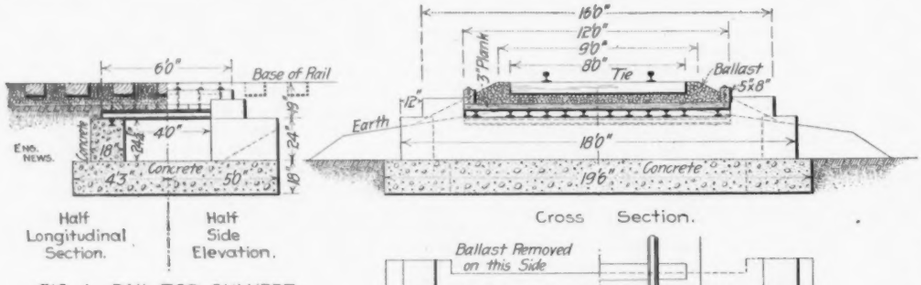


FIG. 1. RAIL TOP CULVERT; A., T. & S. F. RY.

COST OF OPERATION.—The operating expenses have been estimated on the assumption that the central station runs three shifts a day, and wages have been taken at current prices in New York.

COAL.—The cost of coal is calculated on the assumption of 3 lbs. per KW.-hour, with coal at $3 per long ton alongside the pier; water is charged at the cost to the city.

STATION LOAD.—The annual output of the station will be 24,000,000 KW.-hours for the arc and 5,000,000 KW-hours for the incandescent service—a total of 29,000,000 for both. The present incandescent and gas lighting is equivalent to 160,000 16-c. p. connections and uses annually very approximately 4,000,000 KW-hours at the lamps and 5,000 KW-hours at the station.

ANNUAL STATION COST.—The total station expense per year will be $217,500 and the cost per KW-hour 0.75 cts.; this is somewhat higher than is usually assumed, but agrees well with the records of a number of plants.

DISTRIBUTION AND MANAGEMENT.—The cost of maintenance, inspection and testing of the cable and wiring system, of maintenance and labor at the sub-stations, all of which may be classed as general expenses of distribution—and the expenses of administration, including office, insurance and legal expenses, are given in Table IV.

TABLE IV.—Cost of Generating and Distributing Energy.

Station expenses	$217,500
Expenses of distribution	100,000
Management, office, insurance, etc.	50,000
Total	$367,500

This makes the cost of generating and distributing electricity 1.27 cts. per KW.-hr.

"LOST TAXES."—No charge is made for "lost taxes"—such a charge is justifiable only in case the city would be paid additional taxes, if the plant were not built. As a matter of fact, the taxation of the existing companies would not be affected in any way by the operation of this plant.

INSPECTION OF LAMPS.—The cost of inspection, carboning, globe breakage and repairs for arc lamps, and of renewals, metering and general supervision of incandescent lamps, is not included in expenses of distribution above. The cost of maintenance of arc lamps will be $5 per year per lamp, a total of $50,000, and the cost of renewals, etc., of incandescent lamps, 75 cts. per KW.-hr. of station output—a total of $37,500.

Adding these two items to the $100,000 given above for general expenses of distribution, makes the total sum of $187,500 per year for maintenance of the plant, outside of the central station.

DEPRECIATION.—Depreciation is assumed to be equal to 8% of the total of the items of Table III., excluding items 16, 17, 18 and 19—that is, 8% on the total cost of the plant. This amounts to $202,000 per year for the arc and $82,000 for the incandescent service—a total depreciation charge of $290,000 per year. It is therefore equivalent to $20.20 per arc lamp per year and to 1.64 cts. per KW.-hr. for the incandescent service. These amounts are probably considerably in excess of the actual depreciation, and are larger than the value usually assumed to cover this item.

TABLE V.—Cost Per Year Per Arc Lamp.

Energy supply at 1.27 cts.	$30.40
Maintenance	5.00
Depreciation	20.20
Interest	10.50
Total	$66.10

TABLE VI.—Cost per KW.-hour for Incandescent Service.

	Cts.
Energy supply	1.27
Maintenance	.75
Depreciation	1.64
Interest	.72
Total per KW.-hour at station	4.38
Total per KW.-hour at lamp	5.475

ALLOWANCE FOR OUTAGES.—Assuming an average of only 95% of the arc lamps to be in service, the cost per year, allowing for coal not used, will be $69.40.

SMALLER PLANT.—The annual cost per arc light with a plant to supply 5,000 arcs will be $80.80, making the same allowances. The total cost for this plant will be:

Operating expenses	$455,000
Depreciation	290,000
Interest	147,000
Total	$892,000

The comparative costs for the two services will be:

ARC LIGHTS.

Present rate	$146.00
Cost with city plant	69.40
Saving with city plant	$76.60
Saving, in percentage of present rate, 52.4%.	

INCANDESCENT LIGHTING.

	Cts.
Present rate, per KW.-hour	10.0
Cost with city plant	5.475
Saving with city plant	4.525
Saving, in percentage of present rate, 45.2%.	

The total annual cost at present rates and for a city plant, first for 10,000 arc lights and the present lighting of public buildings; and, second, for 5,000 arc lights and the present lighting of public buildings, will be:

Cost of	At present rates.	City plant.
10,000 arc lights	$1,460,000	$694,000
4,000,000 KW.-hrs.	400,000	219,000
Totals	$1,860,000	$913,000
Saving with city plant		$947,000
Saving, in percentage of present rates, 50.9%.		

Cost of	At present rates.	City plant.
5,000 arc lights	$730,000	$404,000
4,000,000 KW.-hrs.	400,000	219,000
Totals	$1,130,000	$623,000
Saving with city plant		$507,000
Saving, in percentage of present rates, 44.9%.		

These tables show that 10,000 arc lamps and the present lighting of public buildings can be operated for about $200,000 less than is now charged the city for 5,000 arc lights and the same lighting of public buildings, and that, approximately speaking, the work can be done for one-half of the present rates.

All the estimates in this report are based on the assumption of economical construction of the plant on a cash basis, and of competent and economical management.

STANDARD PLANS FOR BRIDGES ON THE ATCHISON TOPEKA & SANTA FE RY.

For a large railway system having many bridges, it is generally considered the best and most economical practice to prepare standard plans covering the various classes of structures required, and to reduce the different types and spans of structures to as small a number as possible. The saving both in construction and maintenance, from having these standard plans, will much more than cover their extra cost if they are made on proper lines. During 1896, the Atchison, Topeka & Santa Fe Ry. commenced a series of improvements over its entire system which made it necessary to rebuild the larger portion of its old bridges. The prospects indicated that for several years an annual output of from 5,000 to 12,000 tons of steel bridges would be required, and under these circumstances it was thought best to arrange for a complete set of standard plans. Copies of these plans, representing typical structures, have been furnished us, with other information, through the courtesy of Mr. J. Dun, M. Am. Soc. C. E., Chief Engineer of the Atchison, Topeka & Santa Fe Ry. system.

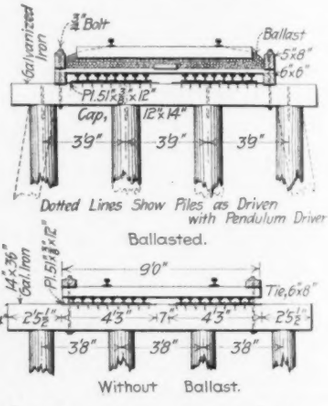


Fig. 2. Rail-Floor Bridge with Pile Bents.

In describing these plans and the matters governing the various designs, we have drawn very largely upon a lecture delivered before the engineering classes of the University of Illinois by Mr. A. F. Robinson, M. Am. Soc. C. E., Bridge Engineer of the Atchison, Topeka & Santa Fe Ry. system, but supplementing this by later and more detailed information furnished us by Mr. Robinson. For the use of this lecture we are indebted to Prof. I. O. Baker, Professor of Civil Engineering at the University of Illinois. Some particulars as to the engine loads on this railway were given by Mr. Robinson in a paper on "Impact and Unit Stresses Allowable in Old Bridges," in our issue of Sept. 25, 1902. The expectations above noted as to the amount of bridge work required have been fully realized, and the work covered by contracts already made for 1903 will aggregate nearly 15,000 tons. In this connection it may be noted that in view of the great amount of bridge work yet to be done, and of the difficulties in obtaining steel and getting the structures erected in the desired time, the engineering department is investigating the desirability of adopting concrete for many of the new bridges. No definite action has yet been taken, but it is probable that where concrete is used, it will not be reinforced by steel in any way, the object being to avoid interference with the work by any stringency in the steel market.

In arranging for the production of a set of standard plans for steel bridges, the first problem

encountered was that of how and by whom the standard plans should be prepared. It was at once evident that if the Bridge Engineer undertook the work, a large staff of assistants and draftsmen would be required, and also that it would very seriously interfere with his regular work of inspecting bridges, supervising renewals, and the multitudinous duties involved in the care

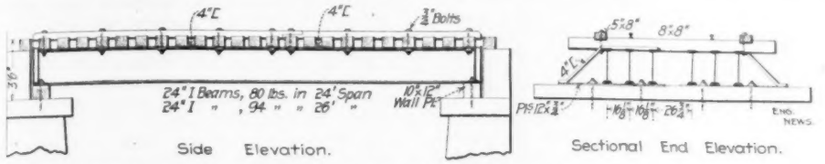


FIG. 3. I-BEAM BRIDGES OF 24-FT. AND 26-FT. SPAN; A., T. & S. F. RY.

of and responsibility for bridges on some 8,000 miles of railway. After some consideration it was decided to take up the matter with the American Bridge Works, of Chicago (now absorbed by the American Bridge Co.), and it was eventually arranged that after determining upon the types and spans required, the Bridge Engineer should make a complete design with strain sheets. The detail drawings and shop plans were then to be prepared in the bridge company's office, and submitted to the Bridge Engineer of the railway company. After his approval, these became the standards for future construction. For this work the railway company paid a specified price per ton for one set of plans of each kind, and the tracings became the property of the railway company.

In this way the theoretical conditions of design and the practical conditions of manufacture were given full consideration, with the result that the work is not only of good design and ample strength, but is also built at a remarkably low price, even as compared with structures built to the standard plans of other railways. For instance, no field bolts are required, all field holes being accessible for riveting. For some years all of the work for the Atchison, Topeka & Santa Fe Ry. has been built by the American Bridge Works plant (Chicago) of the American Bridge Co., and these works are so familiar with the structures that they do not require special detail plans on which to make bids. The contracts are let for a stated price per pound, and all the work is done under the railway company's standard specifications. The shop and mill inspection are intrusted to the firm of R. W. Hunt & Co., which has done this work for the past ten years.

The series of standard plans includes T-rail and I-beam spans of 8 to 34 ft.; deck and through plate girder spans of various lengths from 26 to 106 ft.; and two styles of through truss spans from 110 ft. to 300 ft. in length. These we will consider in turn.

T-RAIL AND I-BEAM SPANS.

For special locations, where the distance from the base of the rail to the bed of the stream or drainage opening is small, a T-rail bridge is used. Fig. 1 shows a rail-top culvert, with concrete base and side walls. There are 12 pieces of rail 6 ft. long, with a deck of 3-in. plank to carry the ballast. A bridge of the same type, 7 ft. 6 ins. span, has 16 rails 10 ft. long; the ends of the rails rest on pieces of old boiler plate ⅜ × 12 ins., on 3-in. timber wall plates. The rail floor bridges have from one to eight spans, resting either on masonry or on bents of treated piles, and sometimes carrying a solid floor with ballast. For pile bridges the span is always 8 ft. in the clear, and eight pieces of 65-lb. rail are used under each traffic rail, as shown in Fig. 2. Such bridges on masonry usually have but one span, and strictly speaking a T-rail bridge supported by piles cannot be considered a permanent structure.

For spans of more than 8 ft. and less than 26 ft., deck girders of steel I-beams are used, the I-beams being in sets and riveted to transverse pieces. When the head room is limited, these I-beam girders are used up to spans of 34 ft. The 12-ft. spans have four 15-in. 50-lb. I-beams; and weigh 3,500 lbs. complete. The 34-ft. spans have ten 24-in. 90-lb. I-beams, and weigh about 33,000 lbs. complete. Fig. 3 shows the construction for spans of 24 and 26 ft. All I-beam bridges have end plates riveted to angle brackets on the webs of the beams, and also have intermediate diaphragm plates fitted between the webs as braces or stiffeners.

PLATE GIRDER SPANS.

For spans of 26 to 106 ft., plate girders are used, and are divided into four classes, as follows:

Class A. For deck spans of economic weight.

Class B. For deck spans of the least depth consistent with good service.

Class C. For through spans with deep floors.

Class D. For through spans with shallow floors.

CLASS A GIRDERS. (Deck Spans.)—These are the lowest in cost, the depth being such as to give what is considered as the least weight possible under the specifications. The proper depth of girder for the lowest weight was found as follows: The web plates are ⅜-in. thick and the minimum pitch of flange rivets through web is 2 ins., where these rivets are in two rows, or 3 ins. if in one row. The depth is equal to the maximum live and dead load shear multiplied by the rivet pitch, and divided by the allowed bearing of rivets on the web. To this depth must be added the distance from the back of top and bottom flange angles to median line of the two rivet pitch lines, or 7 ins. where angles 6 × 6 ins. are used. For a 90-ft. girder this would require a depth of 99 ins. back to back of flange angles, and a depth of 100 ins. has been used. The depths (over flange angles) of the various spans by the above formula will be as follows:

90-ft. girders,	100 ins. deep.	50-ft. girders,	62½ ins. deep.
80-ft. "	90 " "	40-ft. "	55 " "
70-ft. "	80 " "	30-ft. "	47½ " "
60-ft. "	70 " "		

For spans of from 60 ft. to 90 ft., the change in depth is 1 in. for each foot in length; while for spans from 30 ft. to 60 ft. the change is ¾-in. per foot. According to the above rule, spans of 100 ft. should be 110 ins. deep, and 105-ft. spans 115½ ins. deep. They were, however, made 108½ ins. and 114½ ins. in depth from back to back of the flange angles. All deck girders are so spaced that the guard-rail bolts will hook over the outer edge of the cover plates. When Class A spans above about 75 ft. are used, the width c. to c. of girders will be less than the distance from base of rail to masonry. In order to increase the stability against overturning, brackets are riveted to the outer sides of the girders at the shoes, thus making the width out to out equal to the distance from base of rail to masonry.

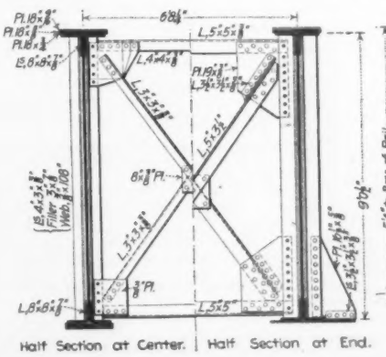


Fig. 4. Cross-Section of Deck Plate-Girder Bridge of 100-ft. Span (Class A, Economical Depth); A., T. & S. F. Ry.

Fig. 4 is a cross-section of a deck plate girder span of Class A, 100 ft. long. It is of the ordinary type of construction, each girder being composed of a web plate, four flange angles, and six cover plates. The top and bottom laterals are single angles riveted to connection plates, and having plates at the intersections. In the top laterals, both angles have the vertical legs downward, so that one has to be cut, a long splice plate being used. In the bottom laterals one angle has the vertical leg upwards and the other has it downwards, so that there is no splicing. The web stiffeners are not crimped, but have filler plates under them. The end cross-section shows the side brackets at the shoes, above referred to.

CLASS B. GIRDERS. (Deck Spans.)—Spans in this class are made as shallow as possible without much reference to the shipping weights; it being less expensive to use these girders than to change the grade line of the roadway. For spans from 30 ft. to 42 ft. in length, four lines of girders are used. For spans above 42 ft., two lines of girders are used for each span, with laterals and cross frames. Class B girders are not built longer than 80 ft., as above that length they weigh more than the Class C girders. With Class B girders, spans from 30 ft. to 42 ft. in length have solid web cross frames at each end and two, three or four intermediate frames. Where four lines of girders are used, they are so placed that each one takes one-fourth of the full track load. No horizontal diagonal lateral bracing is used, but to make these spans as stiff as possible, long batten or tie plates are riveted to the under side of the upper flange angles just forward of all cross frames, except the center set. By this arrangement the girders may be riveted up in pairs at the shops, and the field riveting thereby much reduced. Some five years of hard service for these bridges without laterals, both under curved and tangent track, has failed to show any lack of lateral stiffness. For spans above 42 ft. in length the flanges are made up of side plates next to the webs, then angles and cover plates. The web plates are heavier than in the corresponding spans of Class A girders. The depth of these girders is usually from 1-12th to 1-14th of the span.

Fig. 5 shows the cross-section of a Class B deck plate girder span of 60 ft., the depth of which is only 4 ft. 6 ins. over the flange angles. Each girder consists of a web plate, four reinforcing plates, or side plates, four flange angles and four cover plates. The usual top and bottom lateral bracing is used. Fig. 6 shows the construction of the shorter Class B bridges with four lines of girders. This particular bridge is of 36-ft. span. Attention is called to the solid plate end frames, the intermediate struts, and the horizontal batten plates taking the place of diagonal lateral bracing.

CLASS C. GIRDERS. (Through Spans.)—The main girders are the same depth as the corresponding girders in Class A spans, and a deep floor system is used. Rolled I-beams are used for stringers wherever possible. Floor beams and stringers have ⅜-in. webs and no cover plates. The spans in this class run from 60 ft. to 105½ ft. in length, over all. In long spans of this class

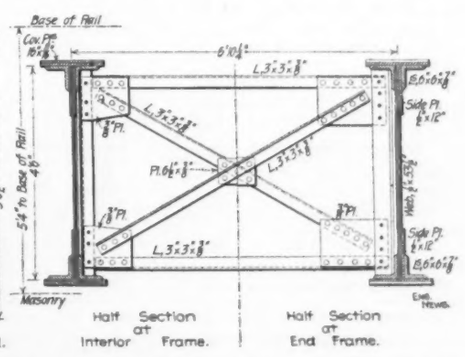


Fig. 5. Cross-Section of Deck Plate-Girder Bridge of 60-ft. Span (Class B, Minimum Depth); A., T. & S. F. Ry.

the flanges have side plates next to the webs, in order to reduce the number of cover plates. Fig. 7 shows one of the girders for a 60-ft. span of Class C, and Fig. 8 shows the floor beam.

CLASS D GIRDERS. (Through Spans.)—The main girders are the same depth as for the Class A spans of corresponding length, while the floors are made as shallow as possible. The panels are

shorter than in Class C spans. The floor beams have heavy webs and cover plates, as shown in Fig. 8. In the 60-ft. spans these beams are only 21 ins. deep, as compared with 42½ ins. for the Class C spans. When spans of this class are more than 70 ft. in length, it is rather hard to properly support the top flange against buckling, as the girders project so far above the tops of the floor beams, that the gussets (as usually made) do not give sufficient support for the upper flanges. In the plans for 100-ft. spans recently made, 7-in. plates were riveted to the stiffeners, and extended from near the tops of the gussets to the upper flange angles. The principal objection to spans of this class, above 70 ft., is the unusual number of gussets projecting above the tops of the beams. While these are made of plates from 7-16-in. to ⅝-in. thick and have flats ½ × 4½ ins. riveted to their flared edges, there is some doubt as to the outcome of a serious derailment. The clear width is only 14 ft. and as the girders project so far above the rails, an end view of the bridge gives a rather unpleasant impression.

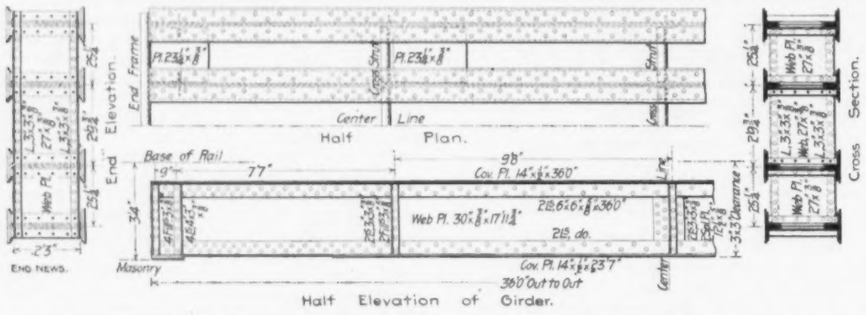


FIG. 6. PLATE-GIRDER DECK BRIDGE OF 36-FT. SPAN WITH FOUR GIRDERS; A., T. & S. F. RY.

PLATE GIRDER BRIDGES.—No deck spans have any end finish; the end stiffener angles are dropped back ½-in. from the ends of the girders and have their roots toward the middle of the span. For flanges of girders and floor beams, angles 6 × 6 ins. are generally used. One span, the 90-ft. Class A, has angles 8 × 8 ins., which were tried as an experiment. Cover plates are generally 14 ins. and 16 ins. wide, the only variation from this being in the case of the long Class D or C spans, where plates 18 to 22 ins. wide are used in the top flanges, and 16 ins. in the bottom flanges. The thickness of plates does not vary by less than 1-16-in. The top and bottom flanges always have the same gross section, this being proportioned for the bottom flange, which is net section, deducting for rivet holes. In all cases the first cover plate in the top flange is the full length of girder, and whenever there are enough covers to require cutting 1 in. in sizing the ties, another plate is made full length. The ties are 8 × 8 ins., 12 ft. long, in all cases, except for truss spans on curves. In most of the spans, ⅜-in. web plates have been used (Class B spans excepted), but it is thought that plates 7-16-in. or even ½-in. thick might show favorable results. Only a few sizes of angles are used in laterals, stiffeners and cross frames. Experience has shown that much more prompt delivery of material can be obtained where only a few sizes of angles or plates are used.

One particular item that should be followed in designing work is to make the rivet spacing as simple as possible, thereby greatly simplifying the shop work. All fractional spaces should be near the ends of the member and no fraction less than 1-16-in. should be used. In girders, beams stringers, etc., Mr. Robinson believes it will usually be possible to so place the rivets that interior spacing will vary in full inches and ends will not show many fractions less than ¼-in. Unfortunately this rule was not adopted for the plans under discussion, as at the time that work was commenced upon them the shop people did not appreciate the full worth of this arrangement. This rule will not apply fully where solid floor bridges are used, such as those used for track elevation work in Chicago.

For all classes of girder spans above 70 ft. in length, bed plates are used which consist of from four to eight Z-bars ⅝ × 4 ins., laid parallel with the main girders and having ¾-in. top and bottom plates. Theoretically, these bed plates should have the rivets fastening the Z-bars to the plates spaced only about 2½ ins. apart. In making the plans only enough rivets were used to properly fasten all parts of the bases together, but inspection under the heaviest loading has failed to detect any spring in these bases. As the deflection is slight, the friction between plates and Z-bars is sufficient to hold the bases together without many connecting rivets.

There are no roller bearings, but the ⅞-in. sole plates resting on the base plates have a bearing face 8 ins. long (parallel with the girder) with the ends beveled. By this means an absolutely uniform distribution of the loading on the masonry is obtained. Some 50 spans of 80 ft. or more in length have been in service from one to five years and there has been no trouble with the expansion, the beveled sole plates appearing to move on the bases almost as freely as though the girders had roller supports. Two special plans are made for girders and floors for curves of 5° and 12°. When girder spans are on curves, the superelevation for the outer rail is made in the pedestal stones. The spans are built exactly the same as for track on tangents, and the regular

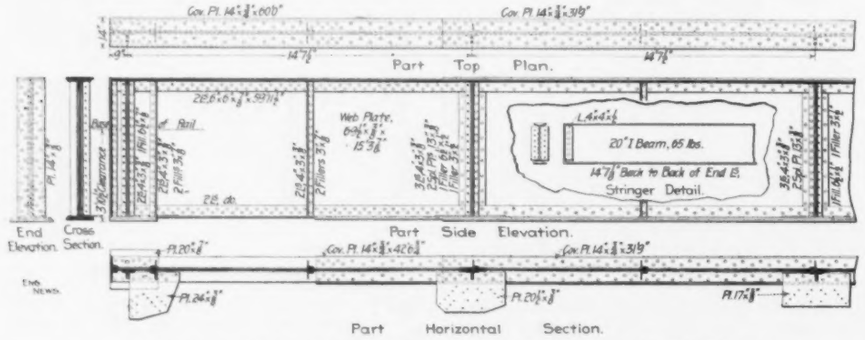


FIG. 7. GIRDER FOR THROUGH BRIDGE OF 60-FT. SPAN (CLASS C).

8 × 8-in. ties are used. As a rule all the bridges are set upon pedestal stones from 18 to 24 ins. high, as this gives a good distribution of the loading on the pier and also reduces the quantity of bridge masonry required, while it permits of men getting around under the bridge for examination.

While skew bridges are not all desirable, it is sometimes necessary to have them. In the standard plans, one skew has been adopted for the piers, namely 45° right or left, while the bridge is squared up at the abutments, the end spans having the abutment end square and the pier end made to the 45° skew. Of course this arrangement can be used only where there are two or more spans in the bridge. Bridges of this type are known as Class A, B, C or D Special. The length of span is taken on center line of track and the shipping weight per span is the same as for square spans of corresponding length.

An examination of the weight sheet, Table No. 1, will show that for any length of span the weights increase from Class A to D. This increase, or the difference between the spans of the four classes of girders is not regular for any given length of span. It is considered, however, that the ideal design should show a regular increase in weight between the various classes. In the tables of weights, the calculated weight plus 2½% is given. If the shipped weight is more than the weight given in the table, the additional excess is not paid for. If it is much less than the weight given in the table, the bridge may be rejected. In this way the builder could derive no benefit from either scamping or padding the material. In fact the entire system of plans, specifications and contracts is designed with a view to be thoroughly fair and equitable to both the railway company and the bridge company.

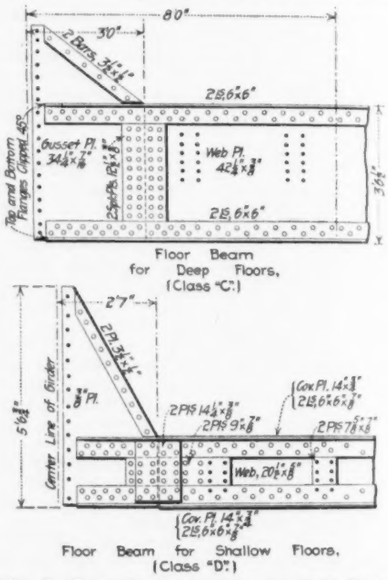


Fig. 8. Floor Beams for Through Plate-Girder Bridges (Class C and Class D); A., T. & S. F. Ry.

TABLE I.—Estimated Weights of Plate-Girder Bridges; Atchison, Topeka & Santa Fe Ry.

Span.	Class A., lbs.	Class B., lbs.	Class C., lbs.	Class D, lbs.
26 ft.	12,800	17,900	.....	.....
30 "	16,000	23,900	.....	34,300
32 "	17,500	25,800	.....	37,100
34 "	20,000	28,600	.....	.....
36 "	21,600	32,100	.....	44,700
40 "	24,300	36,000	.....	49,000
40 ft., 10° curve..	24,600	.....	.....	.....
42 ft.	26,000	39,200	.....	.....
44 "	28,300	36,000	.....	.....
48 "	33,500	45,000	.....	62,400
48 ft., 5° curve...	.....	.....	.....	64,100
48 ft., 10° curve..	.....	.....	.....	64,400
50 ft.	36,900	49,800	.....	68,000
52 "	40,900	50,000	.....	73,000
54 "	42,500	53,500	.....	76,800
58 "	.....	58,500	.....	.....
60 "	51,500	62,400	80,200	90,400
60 ft., 5° curve...	.....	.....	80,600	91,600
60 ft., 10° curve..	.....	.....	81,100	92,600
62 ft.	.....	.....	.....	93,600
64 "	56,100	66,800	88,200	97,700
64 ft., 5° curve...	.....	.....	89,100	.....
64 ft., 10° curve..	.....	.....	89,700	.....
66 ft.	58,600	.....	.....	.....
70 "	68,800	83,300	105,000	112,000
70 ft., 5° curve...	.....	.....	105,800	113,100
70 ft., 10° curve..	.....	.....	106,300	113,900
75 ft.	78,500	94,800	113,200	120,200
75 ft., 5° curve...	.....	.....	113,700	.....
75 ft., 10° curve..	.....	.....	114,000	.....
80 ft.*	88,500	.....	124,100	130,400
90 " *	110,600	.....	159,900	172,200
100" *	133,600	.....	.....	.....
105½ ft.	.....	.....	218,500	.....

*Weights given for girders Class C and D are for round ended girders.

TRUSS SPANS.

The standard designs for truss bridges run from 110 to 300 ft. in length. Two general styles of truss bridges are used, one with deep floors and the other with shallow floors. The latter have bellied floor beams, while those with deep floors have the beams entirely above the pins of the bottom chords. Wherever possible the end floor beams are exactly over the centers of the end pins. When the end floor beam is hung from the end pins, stringer brackets are used extending to the vertical plane passing through the outer ends of the shoes. Experience has shown that the bridges having bellied floor beams and the hitch plates for the laterals fastened to the ends of posts and bottoms of floor beams, are more rigid laterally than where the beams are entirely above the bottom chord pins. This pattern has therefore been used in all recent spans, whether of the deep floor or shallow floor style. In all through truss or girder spans the end floor beams are made strong enough to enable the unloaded span to be lifted by placing jacks under these beams at the stringer connections.

Stiff laterals are used throughout, and the end verticals are built of rolled channels, the same as intermediate posts. All spans of less than 140 ft. have stiff riveted bottom chords. No expansion rollers are used of less than 4 ins. diameter, and for spans of over 164 ft., 6-in. to 15-in. segmental rollers or rockers are used. All spans have deep heavy portals and post brackets, but no curved plates or angles are used. With the pattern adopted, a more rigid structure is obtained than when circular or bent angles are used, and the exterior or architectural effect is sufficiently good. Four lines of stringers are always used, and are so spaced that each carries one-fourth of a full-track loading. The four lines of stringers weigh but very little more than the ordinary double line of main stringers with the outside idlers or jack stringers. All parts of the four-stringer deck are doing equal service, no member being added simply for possible derailments, but in cases of derailment the four stringers give a good substantial working base for clearing up the wreck. Other reasons for the four lines of stringers are as follows: (1) To allow the use of 8 × 8-in. ties and still not have the rails directly over the stringers, thus using the spring of the ties to cushion the blows from traffic; (2) With four stringers less depth is required from base of rail to clearance than in the two-stringer plan; (3) Stringer laterals or cross frames are not needed.

All counters are made adjustable by means of open-sleeve nuts or turnbuckles placed near the top chord. Under ordinary practice the turnbuckles are placed near the bottom chord, where they are readily accessible from the track. Any foreman who hears the bars rattle when a train passes is apt to assume that they are loose, and (regardless of general orders) is apt to proceed to tighten them up by means of a crowbar stuck into the opening of the turnbuckle. With the arrangement above described, if it is desired to adjust the bars, a platform or scaffold must be rigged up on the truss, so that a man is not likely to undertake any adjustment unless he has direct orders to this effect.

Plans for a few spans have been made which show but 2 ft. 6 ins. from base of rail to clearance, but as yet none of these have been put into service. For the above special plans, stiff bottom chords are used with floor panels of about 8 ft. The truss panels are longer and are so taken that no floor beam comes opposite a panel point. Plans of this pattern were made for spans of 100 ft., 126 ft., and 149 ft. in length, respectively. These spans will cost more for manufacture than the ordinary pattern, and are very heavy.

In 1901, Mr. Robinson designed for the crossing of the Los Angeles River, in California, a bridge which is irregular in many ways, not conforming to the standards, but which is mentioned here to show what it is possible to do in case of necessity. There are two 200-ft. and one 134-ft. through truss spans on tangent, and two 90-ft. through girder spans on a 5½° curve. All the piers are skewed about 34 ft. 8 ins. in a width of 16 ft. 6 ins. and the entire bridge is on a descending grade of 0.6% going west. A bridge was obtained which cost no more per pound than the ordinary square spans and in which the only skewed parts were the portals and foot-shoe struts. In the truss spans, the posts project below the bottom chords and have a line of stringers attached thereto on the center line of each truss. The floor beams are 15-in. steel I-beams spaced 20 ins. between centers and resting on shelf angles close to the bottom flanges of the stringers. On top of the floor beams there is a course of 4-in. creosoted planking which is topped out with at least 6 ins. of ballast and an ordinary track. The through girders had a similar floor, and agreed in all particulars with those used for the joint-track elevation work in Chicago which is now being done by the Santa Fe, the Illinois Central and the Chicago & Alton railways. The curve elevation and easement were made in the ballast. This bridge is now in service and promises to be a long-lived structure in which the maintenance charges will be low.

The following table gives the estimated weights for the standard designs of truss bridges of various spans:

TABLE II.—Estimated Weights of Truss Bridges; Atchison, Topeka & Santa Fe Ry.

Span, c to c. of pins. ft.	ins.	Length over shoes, ft.	ins.	Width c to c of trusses, ft.	ins.	Estimated weight, per span, lbs.	Class.
100	0[6]	102	9	16	0	193,700	D
103	0[6]	105	11¼	16	0	183,300	D
110	0	112	9	16	0	195,300	D
124	2	127	5	16	0	236,800	...
126	0[5]	129	3¾	16	0	283,900	D
128	0[5]	131	3	16	0	244,300	...
130	0	133	3	16	0	251,500	...
130	0[4]	133	3	17	9	258,200	...
134	0	137	2½	16	0	263,200	C
149	0	152	0½	16	0	295,500	C
149	0[5]	152	4	16	0	347,500	D
160	0	163	3½	16	0	341,900	D
163	11	167	3	16	1	346,100	C
172	0[3]	174	10⅝	16	0	371,700	C
200	0[2]	202	9⅝	16	0	499,500*	C
210	0[2]	213	0⅝	16	0	490,400†	C
260	0[3]	263	1	16	2	702,400	C
300	0[3]	303	8	18	0	914,500	C

Note.—All truss spans of 140 ft. and less have stiff bottom chords.

*Soft steel. †Medium steel.

[1], [2] and [3]Stiff bottom chord carries floor; [4]130-ft. span shortened; [5]Span for 5° curve; [6]Parallel chords; [7], [8] [9]Chords not parallel.

C—Deep floors; D—Shallow floors.

CONCLUSIONS.

As a result of the care taken in preparing standard designs and the drawings for them, the following advantages have been attained.

1. Bridges that can be manufactured for a very low price per pound.

2. There is a desirable uniformity in appearance.

3. A low cost of erection; this cost has steadily decreased since the adoption of these standard plans.

4. The bridges are very low in first cost and give every promise of being long lived.

5. The masonry is simplified and chances for errors reduced by the use of the standard superstructure plans.

In concluding his lecture, Mr. Robinson explained that while a set of plans carefully designed will prove to be an economical standard for a certain time, the life of such plans has undoubtedly certain limits, as the increase in rolling load and other traffic conditions will, after a comparatively short period, require all the plans to be re-made. In his opinion, however, the gain from having the standard plans will much more than off-set the cost of preparing the designs and making the drawings.

SPECIFICATIONS.

As an appropriate supplement to this article we publish below some extracts from the company's latest revised specifications for steel bridges and viaducts. These have been revised and approved by Mr. James Dun, Chief Engineer, and Mr. A. F. Robinson, Bridge Engineer, of the Atchison, Topeka & Santa Fe Ry. system, and were issued in November, 1902. These specifications are intended to cover all bridges of spans up to 300 ft. For longer spans a special grade of material, special loading, etc., will be required and will be covered by new and special specifications.

SPECIFICATIONS FOR STEEL BRIDGES AND VIADUCTS; ATCHISON, TOPEKA & SANTA FE RY. SYSTEM.

Double-track through truss spans shall generally have but two trusses. For double track through girder spans, two or three girders will be used, as local conditions may require.

Tracks will be 14 ft. c. to c., but within the city limits of Chicago, tracks are 13 ft. c. to c.

In single-track spans the width, c. to c. of trusses, shall never be less than one-twelfth of the span. The panel lengths shall not be more than 25 ft., and in general not more than 1½ times the width c. to c. of trusses.

The timber floor will generally consist of cross-ties 8 ins. × 8 ins. × 12 ft., spaced from 12 to 14 ins. between centers. Guard rails will be 5 × 8 ins., laid on the flat and housed 1 in. over ties. The clear space between guard-rails on tangent track will be 7 ft. 9 ins. Ties will work 7¾ ins. in depth. In estimating dead load, timber shall be taken at 4½ lbs. per ft. B. M.

When girder bridges are on curves, the superelevation for outer rails will be made in the pedestal stones, and timber decks will be the same as for spans on tangent. Where truss spans are on curve, the superelevation of outer rail will be made in the timber deck.

CALCULATIONS.

9. The dead load shall be assumed as uniformly distributed in bottom chords of through spans and top chords of deck spans for spans of 200 ft. or less, and as per special instructions for longer spans. It shall be made up of the following: A, The net suspended weight of metal in the trusses or girders, and all bracing; B, The weight of the timber deck, together with ballast, track and fastenings, shall be taken at 1,400 lbs. per lin. ft. of track. While provision is made above for the use of ballast floor, it will not always be put in when the bridge is built.

10. In addition to the dead load, bridges shall be designed to carry moving loads as shown in the accompanying diagram, Fig. 9. The first column of the table shows the standard moving load which has been in use since 1895, and which is still to be used on all parts of the system except over mountain divisions. The second column shows the heavy-grade moving load which is to be used on mountain divisions.

All plans made for heavy-grade loading shall be so marked. Standard loading shall always be used, unless the orders or requisitions distinctly call for the heavy-grade loading.

The standard moving load consists of two 139-ton consolidation engines coupled and followed by a uniformly distributed train load of 3,200 lbs. per lin. ft. of track. The heavy-grade loading is 50% heavier than the standard, or two 208½-ton consolidation engines and train of 4,800 lbs. per lin. ft. The moving load shall be so placed as to produce maximum stress in each member of every structure.

In double-track spans 130 ft. in length and under, both tracks shall carry the specified moving loading. For double-track spans more than 130 ft. in length, one track shall carry the specified moving loading and the other track a uniform train load of 3,200 lbs., or 4,800 lbs. per ft., as class of loading may require.

	No. 1. Standard loading, (3,200 lbs. per lin. ft.)	No. 2. Heavy-grade loading (4,800 lbs. per lin. ft.)
	22,000 lbs.	33,000 lbs.
	22,000 "	33,000 "
	20,000 "	30,000 "
	20,000 "	30,000 "
	44,000 "	66,000 "
	44,000 "	66,000 "
	44,000 "	66,000 "
	44,000 "	66,000 "
	18,000 "	27,000 "
	22,000 "	33,000 "
	22,000 "	33,000 "
	20,000 "	30,000 "
	20,000 "	30,000 "
	44,000 "	66,000 "
	44,000 "	66,000 "
	44,000 "	66,000 "
	44,000 "	66,000 "
	18,000 "	27,000 "

Fig. 9. Diagram of Engine Loading.

14. The wind pressure shall be assumed as acting horizontally in either direction:

First.—For the loaded structure (vertical effect of live load assumed at 800 lbs. per ft. of track), at the rate of 30 lbs. per sq. ft. on the floor and one truss, plus the area of the leeward truss unprotected by the train, plus 300 lbs. per lin. ft. for the train. The train shall be considered as 10 ft. net height, beginning at 2 ft. 6 ins., above the base of rail, and moving across the bridge. In no case, however, shall the lateral bracing of bridges be proportioned to resist less than the stresses due to an assumed moving load of 1,000 lbs. per lin. ft. of track, 700 lbs. going to the loaded chord and 300 lbs. to the unloaded chord.

Second.—Structure unloaded, wind pressure taken at 50 lbs. per sq. ft. on the exposed surface of all trusses and the floor system. The greater result shall be assumed in proportioning the parts.

Third.—Trestles: With a moving load of 800 lbs. per lin. ft. of track (leeward track only is loaded in double track structures), the wind pressure shall be as above for superstructure (girders and trusses), plus 200 lbs. per vertical foot of trestle towers; the latter is to be applied at the top of each story of trestle bent. Trestle bents shall be so designed that, when loaded as above (800 lbs. per ft.), the maximum assumed wind pressure will not cause tensile strains in the windward legs at the masonry.

For longitudinal bracing of trestle towers the momentum produced by suddenly stopping the train shall be considered; the coefficient of friction of the wheels sliding upon the rails being assumed as 20% of the maximum moving load. Momentum effects used for the bracing in trestle towers shall add no section to the main trestle columns. Each tower must be stable when standing alone, without other help than anchor bolts.

15. When the bridge or viaduct is on a curve, the additional effects due to the centrifugal force of as many trains as there are tracks shall be considered and calculated by the following formula:

C = 0.03 W. D. for a curvature up to 5°, where C = centrifugal force in lbs., W = weight of train in lbs. (equivalent loads), D = degree of curvature. The coefficient for centrifugal force (0.03) shall be reduced 0.001 for every degree of curvature above 5°. When the lateral loading due to curvature is 300 lbs. per ft. or less, it need not be considered in figuring the lateral system.

In estimating the weight of structures, cast iron will be taken at 450 lbs. per cu. ft., and steel at 490 lbs. per cu. ft. Wrought iron is assumed to weigh 480 lbs. per cu. ft.

DETERMINATION OF SECTIONS.

18. No material less than ⅜-in. thick shall be used in any part of structures, except for fillers.

19. The areas obtained by dividing the live load stresses by the live load unit stresses shall be added to the areas obtained by dividing the dead load stresses by the dead load unit stresses to determine the required sectional area of any member.

21. The maximum stresses in tension (net section), shall be as follows, in lbs. per sq. in.:

Members.	Load—Dead, lbs.	Load—Moving, lbs.
Chords and main diagonals—eye-bars	19,000	9,500
Chords & main diagonals—plates & shapes	18,000	9,000
Counters	7,500	7,500
Bottom flanges (girders)—plates & shapes	18,000	9,000
Floor beam hangers—plates and shapes	6,000	6,000
Floor beams and riveted stringers	8,000	8,000
Rolled beams, as stringers & floor beams	*9,000	*9,000
Lateral bracing	15,000	15,000
End verticals—plates and shapes	8,000	8,000

*Pounds per sq. in. on extreme fibers.

22. In compression members the maximum stresses, in lbs. per sq. in., shall be deducted from the following formula and values:

$$\text{Column formula: } B = \frac{S}{1 + \frac{l^2}{a\,r^2}},$$

in which B = allowed stress per square inch.

l = length of member between centers of connections, in inches.

r = least radius of gyration, in inches.

a = { 40,000 for members with two fixed ends. / 30,000 for members with one fixed and one pin end. / 20,000 for members with two pin ends.

S = { 9,000 for main truss members. / 12,000 for lateral struts.

23. Members subject to alternate stress of tension and compression shall be proportioned to resist each of them. Both stresses, however, shall be assumed to be increased by an amount equal to eight-tenths of the least stress.

25. For tension members, only the net sections shall be taken as effective. In deducting rivet holes, they shall be taken ⅛-in. larger in diameter than the nominal size of the rivets.

26. No compressive member shall have an unsupported length exceeding 40 times its least width. In general, compression members shall not have a length exceeding 100 times the least radius of gyration, except for wind bracing, which may have a length not exceeding 120 times the least radius of gyration. The unsupported width of any plate subject to compression shall not exceed 40 times its thickness if the plate is considered in making up the required section.

27. The maximum stresses on pins and rivets, for bearing and shear (in lbs. per sq. in.), and for bending on pins (in lbs. per sq. in. on extreme fibers), shall be as follows:

	Lbs. per sq. in.—Bearing.	Shear.	Bending.
Pins, diameter by thickness of bearing plate	15,000	7,500	18,000
Shop rivets—full heads	15,000	7,500	18,000
Countersunk rivets	12,000	6,000	....
Field rivets in beams and stringers	8,000	4,000	....
Field rivets in lateral connections	12,000	6,000	....
All other field rivets	12,000	6,000	....

28. The maximum shear on the webs of rolled and built beams and girders shall be 6,000 lbs. per sq. in., gross section.

29. In proportioning adjustable members, such as counters and lateral rods, it shall be assumed that each member will be given an initial stress of 10,000 lbs. in the adjustment of the bridge, and the effect of this initial stress shall also be allowed for in the struts to which the laterals attach.

30. Variations in temperature to the extent of 150° F. shall be provided for.

31. The maximum pressure for bed plates on masonry shall not be more than 300 lbs. per sq. in.

32. In long leaf yellow pine or Oregon fir, the maximum bending stress, per sq. in. on extreme fibers, shall not be more than 1,400 lbs. The weight of one driving wheel will be considered as distributed over three ties.

33. Spans up to 106 ft. shall be provided with sliding plates, rocker bearings, or some other acceptable expansion bearings; those exceeding 106 ft. shall have expansion rollers working between planed surfaces, and spans above 164 ft. in length shall have segmental rollers.

34. Rollers must be so proportioned that the maximum pressure per lineal inch of roller shall not exceed 300 × d, d being the diameter of the rollers. No rollers shall, however, be less than 4 ins. diameter for the ordinary kind, and 6 ins. for segmental rollers. All rollers must rest between planed surfaces of steel.

35. When the webs of plate girders (stringers and floor beams excepted) are made heavy enough to go without stiffeners, one-eighth of the gross section of the web shall be taken as flange. In all other cases, plate girders shall be proportioned on the assumption that bending or chord stresses are resisted entirely by the flanges, and that the shearing or web stresses are resisted by the web plates. No part of the webs in these cases will be estimated as flange area.

36. When the thickness of the web of a plate girder is less than one-eightieth of its depth (unsupported depth), the web shall be stiffened at intervals not over 1½ times the depth of the girder. The web shall have stiffeners riveted on both sides, with a close bearing against the upper and lower flange angles. Stiffeners shall, generally, be packed out to the full thickness of the flange angles; when side flange plates are used, the stiffener may be packed out for side plates and angles crimped over flange angles. Stiffeners must be used over bearing points, and at points of local concentrated loading.

37. Pin-connected, riveted, tension members shall have a net section through the pin hole 25% in excess of the net section of the body of the member. The net section back of the pin hole shall be at least 75% of the net section through the pin hole.

38. In calculating the shearing and bearing stresses on the web rivets of stringers, beams and plate girders, the whole of the shear acting on the side next to the abutment is to be considered as being transferred into the flange angles within a distance equal to the depth of the girder.

40. In case the maximum stresses due to wind and centrifugal force exceed half of the maximum stresses due to vertical loading, addition must be made to such sections until these limits are not exceeded.

41. Generally all through bridges shall have four lines of track stringers, which shall be so spaced that each one will take one-fourth of a full track loading. Through spans having solid floor with ballast are the only exceptions to the above rule.

45. The compression flanges of beams and girders shall be stayed against transverse crippling, when their length is more than 16 times their width.

DETAILS OF CONSTRUCTION.

46. All spans (plate girders included) shall be given a camber not less than the deflection under extreme loads. In truss bridges the camber will be given by making the panel lengths of the top chord longer than those of the bottom chord in the proportion of ⅛-in. for every 10 ft.

50. The top flanges of all plate girders (stringers excepted) shall have one cover plate running their entire length; and in deck girders, where the covers will require more than 1 in. housing in ties, more plates shall be run out full length.

53. In proportioning the flanges of girders, 6 and 8-in. angles shall be used, and as large a percentage of the total flange section as possible shall be made of angles. Deck girder spans less than 40 ft. in length will have no bottom laterals, spans 48 ft. in length and over, shall have both top and bottom laterals.

66. Pony lattice girder spans shall be braced laterally by extending the floor beams, and placing gussets outside the trusses in addition to inside gussets.

77. Splices in chord sections shall be of edge-rolled plates, or of angles and edge-rolled plates, and the length not less than twice their width. Abutting joints shall be milled off to exact lengths, and square to the line of chord. Pin holes shall be bored true to the line of stress and correct as to position. No error exceeding 1-32-in. in length of part, or in diameter or in position of pin hole, will be allowed.

78. After milling, each line of chords shall be assembled, the joints matched, their abutting surfaces being brought to a fit by turnbuckles, and all of the rivet holes in the ends of the chords and splices shall be reamed to an exact match and fit. Match marks shall then be made in each piece. The above rule is also to apply to bottom chords when made stiff throughout their entire length; also to tower columns.

89. Rivet holes shall, generally, be not less than 1¼ ins. from the end or side of a plate, and never less than 1½ ins., except in cases where the plate or angle is less than 3 ins. wide. In shapes of all kinds, the pitch line of rivets shall never be less than 1¼ ins. from line to edge of the shape in use.

90. The pitch of rivets shall never exceed 6 ins., or 16 times the thinnest outside plate, nor be less than 2½ ins. for ⅞ or ⅞-in. rivets, in single row; or 2 ins. in staggered rows. In beams, stringers and girders, the rivet pitch shall not exceed four diameters of the rivet for a distance from ends equal to 1½ times the depth of member in question.

For compression members the rivet pitch at the ends shall not exceed four diameters of the rivet for a length equal to twice the width of the member. For punching, the diameter of the die shall in no case exceed the diameter of the punch by more than 1-16-in.

92. All riveted work shall be punched accurately with holes 1-16-in. larger than the size of the rivet, and when the pieces forming one built member are put together the holes must be truly opposite; no drifting to distort the metal will be allowed. If it is necessary to enlarge a rivet hole, it must be done by reaming and not by drifting or use of cape chisels. In assembling, light drifting, to slide the parts sufficiently to make properly punched holes fair, will be permitted. Heavy drifting, which distorts or draws the metal around a hole, will not be permitted.

93. All holes for field rivets must either be reamed through cast-iron templets, or accurate fit guaranteed by contractor. Reaming of rivet holes is not required in any class of work, except to correct imperfect punching or for field holes. As far as is practicable all rivets must be power driven.

95. The rupture of a riveted tension member is to be considered as equally probable, either through a transverse line of rivet holes, or through a diagonal line, where the net section does not exceed by 30% the net section along the transverse line. The number of rivet holes to be deducted for net section will be determined by this condition.

PAINTING.

104. All work shall be given a shop coat of linseed oil, except machine-faced bearing surfaces, which must be coated with a mixture of white lead and tallow. In assembling, all parts coming into contact and which could not be painted after assembling, must be given one good coat of approved mineral paint. No painting or oiling shall be done in wet or freezing weather.

STEEL.

105. All steel must be made by the open-hearth process.

107. All structural steel for bridges and buildings shall conform to the following limits in chemical composition:

	Steel—Acid, %.	Basic, %.
Phosphorus shall not exceed	0.08	0.05
Sulphur shall not exceed	0.06	0.06

Steel castings should have from 0.25 to 0.45% carbon and not more than 0.08% phosphorus.

PHYSICAL PROPERTIES.

108. There shall be three classes of rolled steel, namely: Rivet Steel, Structural Steel, and Eye-Bar and Pin Steel, which shall have the following physical qualities:

	Rivet steel.	Structural steel.	Eye-bar and pin steel.
Ult. strength, lbs. per sq. in.	53,000	60,000	65,000
Ult. strength, lbs. per sq. in.; extreme limits, accepted	48,000 to 58,000	55,000 to 65,000	60,000 to 70,000
Elastic limit, % of ultimate	50	55	55
Elongation, % in 8 ins.	26	25	22
Reduction of area at fraction, %	55	50	40

For each increase of ⅛-in. in thickness above ¾-in., a deduction of 1% shall be made from the specified elongation. For pins the elongation specified shall be reduced 5%, as determined on a test specimen, the center of which shall be taken 1 in. from the surface of the pin.

110. Full-size tests of eye-bars must show not less than 12½% elongation in 15 ft. of the body of the bar, and the tensile strength shall not be less than 55,000 lbs. per sq. in. The bars shall be required to break in the body, but should a bar break in the head and show 12½% elongation in 15 ft. and the tensile strength specified, it shall not be cause for rejection, provided not more than ⅛ of the total number of bars tested break in the head; otherwise the entire lot which they represented will be rejected.

111. All classes of rolled steel shall conform to the following bending tests. And for this purpose the test specimen shall be 1½ ins. wide, if possible, and for all material ¾-in. or less in thickness the test specimen shall be of the same thickness as the finished material from which it is cut. For material more than ¾-in. the test piece may be ½-in. thick. Rivet rounds shall be tested of full size as rolled:

Rivet steel and structural steel shall bend, cold, 180° flat on itself without fracture on the outer side of the bent portion. Eye-bar and pin steel shall bend, cold, 180° around a diameter equal to the thickness of the specimen tested, without fracture on the outer side of the bent portion. Bending tests may be made by pressure or by blows.

THE FAILURE OF A HIGHWAY BRIDGE UNDER AN ELECTRIC CAR AT BINGHAMTON, N. Y.

We illustrate in the accompanying cut the wreck of the north span of the highway bridge across the Susquehanna River, at Binghamton, N. Y. This bridge was built in 1874 and the wrecked span collapsed under the weight of an electric car on May 20, the span and the car, with its passengers and crew, falling some 20 ft. to the river bed beneath. Six passengers and the motorman and conductor were thrown into the water, but none of them were fatally injured. As will be seen from the illustration, the car did not even leave the bridge, but remained, tilted a little to one side, on the bridge floor as it rested on the water.

VIEW SHOWING WRECK OF HIGHWAY BRIDGE UNDER AN ELECTRIC CAR AT BINGHAMTON, N. Y.

The exact cause of the accident has not been determined, but it is supposed to have been the general weakness of the bridge due to its age and the fact that it was carrying loads for which it was never designed. The bridge was a bowstring truss structure and was built at a cost of $35,194 in 1874. A correspondent writes that when the structure was erected it was considered to be

> the best bridge in this part of the country, and it was supposed that it would be equal to any traffic that would ever be placed upon it. But electric cars were not dreamed of then, and for the past ten years the bridge has been subjected to much heavier traffic than for what it was designed. For the past two years the bridge has been considered to be dangerous by the public, but engineers have declared it safe. The exact cause of the accident has not been determined, but it is supposed to have done due to a general weakening of the iron work, by the severe strain that has been placed upon it. The city authorities have already ordered plans and specifications for an entire new superstructure, more suitable for the heavy traffic.

SAND-CEMENT FOR CONCRETE WORKS REMOTE FROM TRANSPORTATION LINES.*

By Edward Duryee.

Investigations were made under instructions from Mr. J. B. Lippincott, of the U. S. Geological Survey, in order to ascertain means of lessening the cost of Portland cement in the construction of dams on the Gila River in Arizona. Owing to the remoteness of these proposed dams from lines of transportation, the expense of bringing cement to the sites makes a notable addition to the cost over construction elsewhere, and it is therefore of great importance to reduce the quantity of cement to the smallest allowable amount.

The investigation of cement for the Gila River dams has been along three lines: (1) To ascertain whether by unusually fine grinding of the cement its strength can be appreciably enhanced and the quantity correspondingly reduced; (2) whether it is feasible to use the rocks found at the dam sites for making a sand-cement; (3) whether Portland cement can be economically made at these sites.

Sand-cement is a term applied to a mixture of cement and sand ground together in a dry state to an impalpable powder. As a rule Portland cement and quartz sand are the materials thus used. This mixture is then used with ordinary sand and gravel, as in the customary practice. The proportion of pure cement is thus considerably reduced, but the strength and durability of the concrete has been found to be nearly as great as that made with the undiluted cement. The explanation offered for the remarkably good results obtained with sand-cement when used with ordinary coarse sand is that the voids in the coarse sand are nearly filled with the finely ground sand. The grains are thus bonded together and to the coarse sand by the uniformly diffused particles of the fine cement. The amount of voids in the ordinary sand, in other words, is greatly reduced by the fine sand, fulfilling the requirement for a strong mortar that must be of dense character, the grains being of such graduated size and so well mingled as to afford the maximum contact of the surfaces of the particles.

In sand-cement mortar the grains of sand are extremely minute, the mixture being so fine that only 5% residue is left on a screen of 200 meshes to the linear inch or 40,000 meshes to the sq. in. The great density thus obtained contributes to the imperability to water and increases the compressive strength and load-bearing capacity, thus rendering the mass of value for constructing foundations, dams, and sea walls.

In the tests made in this investigation a rock known as pearlite, an acidic lava or rhyolite from the Buttes dam site, was used, and also samples of quartzite from the San Carlos dam site. These were chosen because of the abundance of these rocks at the localities named and their superior hardness. The Portland cement used was that manufactured at Colton, Cal., this being made nearest to the place where it will be used and being sold at a lower price than other Portland cement in the local market. All of the tests were made with the same sample of cement, portions of this being taken for the several mixtures with crushed pearlite and quartzite. The sand used with the foreign cement in making sand-cement was clean beach sand from dunes along the coast.

Results of the tests of the sand-cements and comparisons with other mixtures are given in the accompanying table. In each case the crushed pearlite was mixed with an equal weight of cement, and the mixture was ground in a mortar until it all passed through a screen having 200 meshes to the linear inch. The same method was pursued with the quartzite from San Carlos, thus making sand-cements composed of equal parts of Portland cement and pulverized rock ground to an exceedingly fine condition.

The coarse sand used in making the mortar with the sand-cement and with the pure (Portland) Colton cement was of the ordinary grade of fineness used for making cement tests. It was screened from ordinary gravel, all residue on the 20-mesh screen being rejected and all left on the 30-mesh screen being retained.

The briquettes for testing were made according to the specifications recommended by the American Society of Civil Engineers. After the briquettes were made they were kept under a damp cloth for 24 hours, then placed in vats of water, where they were left until the time for breaking arrived, namely, 7 or 28 days. The fine grinding and diluting of the Portland cement with fine sand did not materially affect the time of hardening or setting. The beginning of the setting process of the ordinary Colton cement mortar, or initial setting, was 33 mins., and the time of final setting was 85 mins. This applies to samples Nos. 3, 4, and 9 of the following list. The corresponding periods for the sand-cement were 30 and 80 mins. The cement mortar continues to harden and increase in firmness for a year or longer.

Comparison of test No. 3 with No. 5, and of No. 4 with No. 6, shows that increased fineness of grinding very materially increases the strength and sand-carrying capacity of cements. The ordinary Colton cement of tests No. 3 and No. 4 was ground finer than commercial Portland is usually ground. Recent improvements in mills for grinding render possible a reduction in size of cement grains at a cost which is small when compared with the great increase in the value of the resulting material. Where the freight charges are high, as is the case at the locations under consideration, it is especially important to take advantage of this improvement, and there is no doubt that if the specifications call for a fineness such that only 1% is to be left on a 100-mesh screen, the manufacturers will respond to the requirements. Engineering specifications have ordinarily allowed a residue of 5% on a 50-mesh screen, although manufacturers have for some years permitted a residue of only 1 or 2% on a 50-mesh screen.

In order to obtain the crushing strength of the various cements and concrete considered, two 1-in. cubes of each were broken. The results given are the averages of the crushing strength of the two cubes. The cubes were allowed to remain 20 days in water and then 20 days in the air.

Crushing Tests of 1-in. Cubes.

Character of mixture.	Water, %	Average crushing strength, Tons.
Standard Colton cement	18	3.25
Colton cement, 1 part, and ordinary testing sand, 2 parts	8	1.75
Colton cement, 1 part, and marble sand, 2 parts	8	2.38

Crushing tests were also made of 6-in. cubes of concrete after these had been immersed for 30 days in water. The portions of the mixture and the breaking strain in tons are given in the following table. In the mixture the proportions are given by volume and not by weight.

Crushing Tests of 6-in. Cubes.

Character of mixture.	Breaking strength, tons.
Colton cement, 1 part; ordinary sand, 3 parts; pebbles from gravel, 6 parts	38
Colton cement, 1 part; sand, 3 parts, crushed marble, 6 parts	
Colton cement, 1 part; sand, 2 parts; crushed marble, 5 parts	20

It is believed that concretes of approximately equal value can be obtained by using cements in the following proportions, measured by volume:

Portland cement, 1; sand, 3; broken stone, 7.
Sand cement, 1; sand, 2; broken stone, 6.

COST OF SAND-CEMENTS.—In the Portland cement concrete made in the proportion of cement 1 part, sand 3 parts, and broken stone 7 parts, it has been found that 270 lbs. of cement will be required for a cubic yard of concrete. This, at 2.12 cts. per pound, will cost $5.72 per cu. yd.

In the sand-cement concrete of the proportions 1 cement, 2 sand, and 6 stone, 340 lbs. of sand-cement would be required for each cubic yard of concrete. This, at 1.2 cts. per pound, would cost $4.08.

The saving in the cost of cement to be effected by using sand-cement instead of the Colton Portland willl be the dif-

Results of Tests of Portland Sand-Cements.

No.	Materials.	Portland cement to Sand.	Fineness—50 mesh, %	Fineness—100 mesh, %	Fineness—200 mesh, %	Water, %	Strength—7 days, lbs.	Strength—28 days, lbs.
1	Colton and Buttes pearlite, 1 to 1	2 1 to 5	0.00	0.00	0.00	10	80	300
2	" and San Carlos quartzite, 1 to 1	2 1 to 5	.00	.00	.00	10	90	345
3	" regular	2 1 to 2	.42	7.20	33.20	10	170	385
4	" regular	3 1 to 3	.42	7.20	33.20	10	140	240
5	" fine ground	2 1 to 2	.00	.00	(a)	12	370	465
6	" fine ground	3 1 to 3	.00	.00	(a)	12	170	260
7	" and Butte pearlite, 1 to 1	3 1 to 7	.00	.00	.00	10	75	155
8	" and San Carlos quartzite, 1 to 1	3 1 to 7	.00	.00	.00	10	55	185
9	" regular	0 1 to 0	.42	7.20	33.20	18	615	960
10	Imported	0 1 to 0	.80	7.80	29.33	18	345	525
11	" and sand, 1 to 1	2 1 to 5	.00	.00	.00	10	115	190
12	"	2 1 to 5	.00	.00	(a)	10	125	185
13	"	3 1 to 7	.00	.00	(a)	10	55	90
14	"	3 1 to 7	.00	.00	.00	10	90	140
15	" regular	2 1 to 2	.80	7.80	29.33	10	210	270
16	"	3 1 to 3	.80	7.80	29.33	10	120	175

(a)Some left on 200-mesh screen.
Note.—The above cement stood the boiling test for free lime satisfactorily.

*Abstracted from a paper in Bulletin No. 213 of the U. S. Geological Survey.

ference between $5.72 and $4.08, or $1.64 per cu. yd. of this concrete entering into the construction of the dam. From the total saving thus realized should, however, be deducted the cost of the plant required for grinding the sand-cement.

Concrete blocks composed of the above proportions were crushed at McGill University in 1898, with the following results:

Sand cement, 1; sand, 2; broken stone, 6; water, 20%. Weight per cu. ft., 154 lbs. Crushing load, in pounds per square inch: 7 days, 521 lbs.; 28 days, 639 lbs.; 60 days, 670 lbs.

A concrete of German Portland of the proportions of 1 cement, 2 sand, 6 broken stone, and 20% water stood a load of 728 lbs. per sq. in. in 28 days, and one of the same proportions made from English Portland stood 698 lbs. in 28 days.

Tests for crushing strength on 6-in. cubes of concrete, made of 1 part sand-cement, 2 sand, and 3 parts gravel, were made on concrete that was taken from the bucket just as it was ready to be laid in the foundation of the Cathedral of St. John the Divine, in New York city. Each result is the average of the crushing strength of four separate cubes, made under exactly the same conditions at different periods:

7 days old crushed at	77,162	lbs.
14 " " " "	83,225	"
30 " " " "	92,405	"

Approximate Cost of Plant for Making Sand-Cement; Capacity, 240 Barrels per 24 Hours.

Crusher (required also for crushing rock for concrete)	$2,000
Mill for coarse grinding	2,000
Tube mill for finishing	2,500
Engine and boiler	1,500
Setting up machinery	1,000
Buildings and bins	1,000
Total	$10,000
Cost of mill per barrel of cement, 20 cts.	....
Add, for concrete making, a power mixing machine	1,500

In making concrete, if a good quality of stone be used and the rock be crushed so as to be well graduated as to sizes, thus securing a minimum of voids, the compressive strength of the concrete increases as the proportion of stone increases and as the volume of voids between the stone decreases, and decreases as the proportion of sand in the mortar increases. The rule, therefore, holds: to secure the greatest strength mix the maximum quantity of stone with a minimum of sand mortar sufficient to bond the stone together, the sand mortar being rich in cement. An extensive bed of exceptionally good sand for mortar was found near the Buttes, the grains graduating in size from very small to large sizes. It shows only 35% of voids, while the standard cement-testing sand used in laboratories has 45% of voids.

A large tube mill will grind 10 bbls. of sand-cement per hour to the requisite degree of fineness, at an estimated cost of 20 cts. per bbl. The cost of power for grinding is calculated at 3 cts. per HP. per hour at the dam site.

Cost of Sand-Cement With Portland Cement at $8 Per Barrel.

One-half barrel Portland	$4.00
One-half barrel crushed & coarse-ground quartzite	.18
Grinding same in a tube mill	.20
Royalty on account of sand-cement patent	.05
Total cost of sand-cement per bbl. (375 lbs.)	$4.43

The cost of sand-cement per pound, quartzite being used as the source of the sand-cement, would therefore be 1.2 cts.

The cost of the mill per barrel of cement, 20 cts., is not included in the above.

It is estimated that the cost per barrel of Colton Portland cement delivered at the dam site will be $8. This, for 375 lbs. weight cement, would make the cement cost $2.12 cts. per lb.

On account of the failure to find suitable clays near the dam site, and also owing to the difficulty of obtaining fuel, it is impracticable to manufacture Portland cement there.

LARGE PORTABLE BINS FOR CRUSHED STONE.

The cost of dismantling and setting up a large bin for crushed stone may be $50 or more, to say nothing of lost crusher time. In fact this item of lost time frequently makes it undesirable to move a stone crusher on roadwork, even where the haul has become unnecessarily long. We illustrate in Figs. 1 and 2 a 50-ton portable bin, made by the Acme Road Machinery Co., of Frankfort, N. Y., which, so far as we know, is the largest portable bin yet made. A bin of this size will hold at least half the daily output of a good-sized portable crusher. A neat feature of the design of this portable bin is shown in Fig. 1, where it is seen that the stone too large to pass the last screen section is delivered through a chute upon a belt conveyor which returns the stone to the crusher.

FIG. 1. ACME 50-TON PORTABLE STONE BIN IN USE.

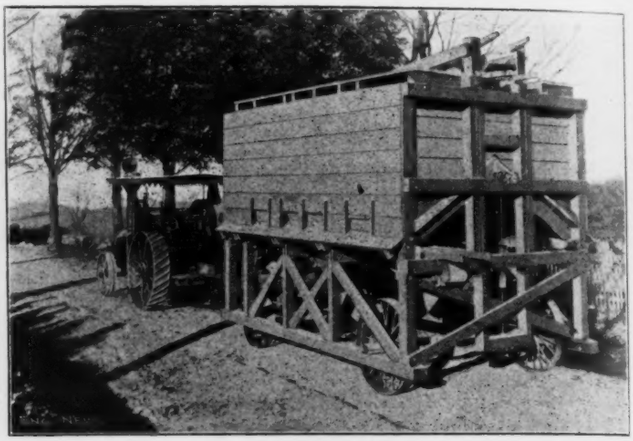


FIG. 2. 50-TON PORTABLE BIN ON THE ROAD.

The photograph of the bin on the road, Fig. 2, was taken just two hours after dismantling was begun.

The screen gearing is so designed that the screen may be rotated in either direction, thus insuring equal distribution of material upon both sides of the inverted V-shaped bottom of the bin. In moving, the screen is lowered so as to reduce top heaviness, and as shown in Fig. 2, the same traction engine used to drive the crusher may be used to move the bin to its new site.

AN ASSOCIATION OF DREDGING CONTRACTORS has been formed to oppose the plan of building Government dredges for work on the Great Lakes. The Association expects to show that dredging done by contract is cheaper for the Government than dredging by day labor with Government dredges. The officers of the organization are: President, W. A. Lydon, Chicago; Vice-President, C. Niederman, Milwaukee; Secretary-Treasurer, C. J. Connell, Chicago; Second Vice-Presidents, E. J. Hingston, Buffalo; W. C. Jones, Cleveland; John Breyman, Toledo; Michael Sullivan, Detroit; H. W. Hubbell, Saginaw; Henry Hickler, Sault Ste. Marie; Robert Smith, Duluth; Harry C. Lydon, T. C. Lutz, Chicago; W. J. Daley, Ogdensburg; John R. Williams, West Superior. An executive committee will meet monthly in Chicago at the Chamber of Commerce Building.

WATER WASTE AT CHICAGO, amounting to 75 to 85% of the supply, still continues, and in some sections of the city very little water can be obtained on the third floors of buildings, except during the night. The City Engineer, Mr. Ericson, says he cannot help matters or accept any responsibility for the conditions. For four years he has endeavored to secure the introduction of the meter system, but without success. While the pumping plants are being worked to their full capacity there is an insufficient supply, owing to leaky plumbing and general waste. The only relief is to limit the use of lawn sprinklers to the hours of 5 to 7 a. m. and 6 to 10 p. m. In 1890, with a population of 1,208,669, the daily pumpage was 152,372,288 gallons, or 126 gallons per capita. In 1900, the population had increased to 1,907,695, the daily pumpage to 322,599,630 gallons, and the per capita consumption to 169.6 gallons. Last year the daily pumpage was some 365,000,000 gallons, giving a per capita consumption of 170 gallons.

THE PURIFICATION OF STRAWBOARD WASTES is to be investigated experimentally at the Massachusetts Institute of Technology, Boston, under the direction of Prof. Wm. T. Sedgwick; at Earlham College, Richmond, Ind., under the direction of Prof. Robert L. Sackett; and at Purdue University, Lafayette, Ind., under the direction of President W. E. Stone, and Prof. Severance Burrage. The co-operation of these men has been secured by the U. S. Geological Survey, which is extending its work on the water resources of the country to include water pollution. Mr. M. O. Leighton, a graduate of the Massachusetts Institute of Technology, and for a number of years health inspector at Montclair, N. J., is hydrographer in charge of these studies. Strawboard wastes are a most troublesome source of water pollution in some parts of the country, and particularly in the region north of the Ohio River. The character of the nuisance is thus described in a recent bulletin of the U. S. Geological Survey:

Strawboard waste is composed of small particles of straw, which, in the violent process generally used to reduce the stalks to their component cellulose fibers, are broken and ground to such a state of fineness that they readily pass out of the washing machine along with the waste water. This material is composed largely of the hard, glazed covering commonly observed on all straw stalks, and, as it contains a high proportion of silica, it is extremely difficult to treat or to utilize in a satisfactory manner. In addition to the straw particles there are varying quantities of waste lime and a fairly high proportion of extractive matter. This waste mingles with other organic matter in a stream, and as a result there is produced a foul, reeking mass, which absolutely destroys fish life, ruins for agricultural purposes land which it overflows, unfits water for domestic supply, and is often highly damaging to residential property.

THE REMOVAL OF THE TELEGRAPH LINES of the Western Union Telegraph Co. from the right of way of the Pennsylvania R. R. Co., which was ordered by the railway company about a year ago is legally authorized by the United States Circuit Court of Appeals in a recent decision written by Judge Dallas. The opinion states that the litigation is before the court on two appeals. One of them is upon a writ of error relating to an order of the Circuit Court of Western Pennsylvania dismissing a petition by which the Western Union Telegraph Co. sought to acquire by condemnation the use of the right of way of the Pennsylvania Co. and its branches for the use of the telegraph company's lines. The other is upon a decree of the Circuit Court of New Jersey awarding an injunction restraining the railroad company and others from interfering with the telegraph lines along the right of way of the Pennsylvania R. R. Co.

The opinion concludes as follows:

Having reached the conclusion that the fundamental position of the telegraph company in each of these cases is untenable, the Circuit Court of Western Pennsylvania is affirmed and the decree of the New Jersey Court is reversed.

The fight between the Pennsylvania R. R. and the Western Union Telegraph Co. began last summer, and in the fall, when the controversy had progressed to the courts, it became known that on June 1 the railroad officials had delivered their ultimatum to the telegraph concern, ordering it to remove its poles and wires from the lines of the railroad before June 1, 1903. Later it was announced that the ousting order was to go into effect on Nov. 1. One thousand telegraph offices of the Western Union are affected by the controversy, and if the railroad wins finally 25,000 miles of wire will have to come down. The case will probably be carried to the United States Supreme Court.